US Anatomy of Thyroid and Neck (Lecture and Live Demo)

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Ultrasonography (US)-guided procedures such as ethanol ablation, radiofrequency ablation, laser ablation, and core needle biopsy have been widely applied in the diagnosis and management of thyroid and neck lesions. For a safe and effective US-guided procedure, knowledge of neck anatomy, particularly that of the nerves, vessels, and other critical structures, is essential. Knowledge of these areas may be helpful for maximizing the efficacy and minimizing the complications of US-guided procedures for the thyroid and other neck lesions. Knowledge of US-based thyroidal and perithyroidal anatomy, its clinical significance, and prevention techniques may help in the early detection, prevention, and proper management of complications during US-guided procedures.

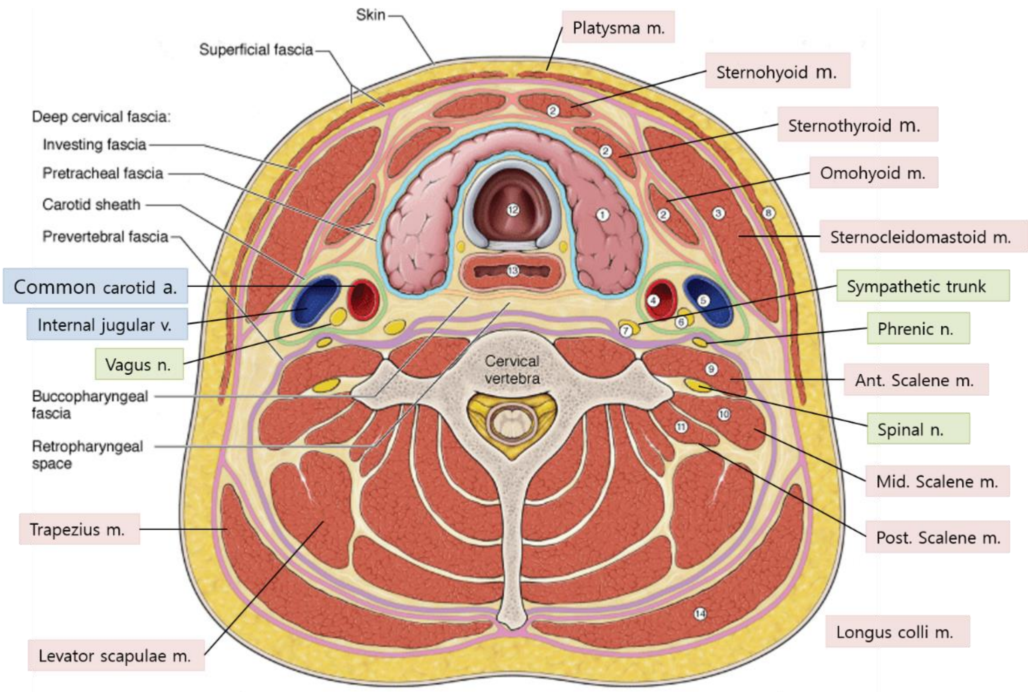

Figure 1. Anatomy of thyroid and perithyroidal structure

Thyroid Gland

The thyroid gland is divided into two lobes connected by the isthmus, which crosses the midline of the upper trachea at the second and third tracheal rings. In its anatomic position, the thyroid gland lies posterior to the sternothyroid and sternohyoid muscles, wrapping around the cricoid cartilage and tracheal rings. It is located inferior to the thyroid cartilage, typically corresponding to the vertebral levels C5-T1. The thyroid attaches to the trachea via a consolidation of connective tissue, referred to as the lateral suspensory ligament or Berry's ligament. This ligament connects each of the thyroid lobes to the trachea. The thyroid gland, along with the esophagus, pharynx, and trachea, is found within the visceral compartment of the neck, which is bound by pretracheal fascia.

The "normal" thyroid gland has lateral lobes that are symmetrical with a well-marked centrally located isthmus. The thyroid gland typically contains a pyramidal extension on the posterior-most aspect of each lobe, referred to as the tubercle of Zuckerkandl. Despite these general characteristics, the thyroid gland is known to have many morphologic variations. The position of the thyroid gland and its close relationship with various structures brings about several surgical considerations with clinical relevance.

Physiologic Variants

Ectopic thyroid tissue can be found anywhere along the migratory pathway and has been documented in locations ranging from the tongue to the diaphragm. The prevalence of an ectopic thyroid gland is between 1 per 100,000 and 1 per 300,000. The most common site for ectopic thyroid tissue is the ectopic lingual thyroid at the base of the tongue.

The thyroid gland may have a pyramidal lobe that extends superiorly from the isthmus. The pyramidal lobe is a normal vestigial remnant of the thyroglossal duct. This has been documented to occur in 28% to 55% of individuals. Most commonly, the pyramidal lobe will originate on the left side of the thyroid. The pyramidal lobe can be separated entirely from the main thyroid gland and has also been documented to occur bilaterally.

In addition to a pyramidal lobe, a wide variety of morphologic variations exist. The isthmus may be large, narrowed, or entirely absent. The lateral lobes may vary in size and symmetry when comparing right to left.

Muscular Structure

Muscles are the basic structures of the thyroid and neck anatomy. Here described the muscles that are most commonly examined in practice.

Anterior Neck Muscles

The strap muscles are a group of 4 pairs of muscles in the anterior part of the neck consisting of the thyrohyoid, sternohyoid, omohyoid, and sternothyroid muscles. The strap muscles originate from or insert into the hyoid bone, and function to depress the hyoid bone and larynx during swallowing and speech. Because the sternothyroid and thyrohyoid muscles attach to the thyroid cartilage, the thyroid gland moves together during swallowing. The omohyoid muscle consists of superior and inferior bellies. The inferior belly forms a flat, narrow fasciculus at the lower part of the neck, and becomes tendinous behind the SCM muscle. The tendinous portion of the omohyoid muscle can be misdiagnosed as a mass on transverse US; however, it can easily be identified by following the oblique course of the muscle on US.

The SCM muscle passes obliquely across the side of the neck, and is located anteriorly at the lower neck. It is composed of 2 separated heads: the medial sternal head and the lateral clavicular head. Because the SCM muscle is thick and broad in shape, it is used as a primary muscular landmark of the neck and divides the neck region into anterior and posterior cervical triangles, which helps define the location of structures, such as the lymph nodes.

Lateral Neck Muscle

The SCM muscle, scalene muscle, levator scapulae muscle, and trapezius muscle comprise the lateral part of the neck muscles. The scalene muscles are a group of 3 pairs of muscles in the lateral neck (anterior, middle, posterior). They originate from the transverse processes of the cervical vertebrae of C2 to C7, and insert into the first and second ribs. Because the cervical/brachial plexus passes between the anterior and middle scalene muscles, the scalene muscle could be an anatomical landmark for the cervical/brachial plexus, and the interscalene space is targeted with the administration of regional anesthesia for a brachial plexus block. The phrenic nerve also passes anteriorly to the anterior scalene muscle.

The levator scapulae muscle originates from the dorsal tubercles of the transverse processes of C1–4, and inserts into the medial border of the scapula. Because the SAN passes between the lateroposterior border of the SCM muscle and anterior border of the trapezius muscle, on the superficial aspect in the middle part of the levator scapulae muscle, these muscles are used as anatomical landmarks for the SAN.

Posterior Neck Muscle

The longus colli muscle and longus capitis muscle consist of the posterior part of the neck muscles. The longus colli muscle is in front of the spine and is the anatomical landmark for the cervical sympathetic trunk that lies on the longus colli muscle. The longus capitis muscle arises by 4 tendinous slips from the anterior tubercles of the transverse processes of C3–6. This anatomical feature easily differentiates the anterior tubercle of the transverse process from the calcified lymph node.

Vascular Structure

The thyroid gland has a rich blood supply, derived from the superior, inferior, and small inferior thyroid arteries that often directly originate from the aortic arch. Venous drainage occurs via multiple surface veins draining into the superior, middle, and inferior thyroid veins. Vascular injury could occur during the biopsy, minimally invasive treatment, or nerve block. Hematoma can be controlled by simple compression of the neck for 15–20 minutes; however, it may require drainage procedure when complicated with abscess formation. Here discussed the arterial and venous structures that are most commonly examined in practice.

Superior and Inferior Thyroid Artery

The superior thyroid artery arises from the external carotid artery just below the level of the greater cornu of the hyoid bone, and primarily supplies the upper and anterior part of the thyroid gland. The inferior thyroid artery arises from the thyrocervical trunk and supplies the posteroinferior parts of the gland. It is used as an anatomical landmark for the middle CSG. The superior thyroid artery is also used as an anatomical landmark for the external branch of the SLN.

In 10% of the population, there is an additional artery known as the thyroid ima artery. This artery has a variable origin, including the brachiocephalic trunk, aortic arch, the right common carotid, the subclavian, the pericardiacophrenic artery, the thyrocervical trunk, transverse scapular, or internal thoracic artery. The thyroid ima most commonly originates from the brachiocephalic trunk and supplies the isthmus and anterior thyroid gland.

Injury to the superior or inferior thyroid artery can be induced by inserting the needle or electrode at the upper and anterior part of the thyroid gland. Injury to the inferior thyroid artery is more likely to result in serious problems. Because it occurs at the posteroinferior part of the thyroid gland, direct compression of the neck is less effective for bleeding control, and may cause a large amount of hematoma.

Common Carotid Artery and Internal Jugular Vein

The CCA and IJV are typically visualized laterally adjacent to both thyroid lobes. The CCA ascends within the neck to the upper edge of the thyroid cartilage, and divides into the internal and external carotid arteries. The CCA runs behind the SCM muscle and medial to the IJV, and intersects the superior bellies of the omohyoid muscle half way up the neck. It is necessary to measure a safe distance from the needle tip before firing the stylet for a CNB of thyroid nodules to prevent CCA injury.

The IJV originates from the jugular foramen at the base of the skull. It descends within the neck along the lateral wall of the pharynx, posterior to the internal carotid artery, and continues laterally to the CCA. It runs beneath the SCM muscle, and finally merges with the subclavian veins forming the brachiocephalic vein.

Superior, Middle, and Inferior Thyroid Veins

The thyroid gland drains into 3 main veins, the superior, middle, and inferior thyroid veins, and each drains its respective region of the thyroid. The inferior thyroid vein arises in the venous plexus on the thyroid gland, communicating with the middle and superior thyroid veins. The superior and middle thyroid veins drain into the IJV, whereas the inferior thyroid vein drains into the brachiocephalic veins.

Anterior Jugular Vein

The anterior jugular vein begins near the hyoid bone, and descends between the median line and anterior border of the SCM muscle. It varies considerably in size, usually inversely proportional to the external jugular vein. In most cases, there are 2 anterior jugular veins, a right and left, but occasionally only 1 vein. It can be damaged when inserting the electrode or needle by a trans-isthmic approach in minimally invasive treatment. Because it is easily collapsed by the US probe, operators should apply soft pressure to identify the anterior jugular vein. Although injury to the anterior jugular vein can be easily controlled by simple compression, it can disturb the procedure due to persistent oozing.

Bone and Cartilage

Bone and cartilage are the center of the thyroid and neck structures. Bony structure includes the hyoid bone and vertebrae, and appears as a bright hyperechoic linear structure with a hypoechoic acoustic shadow underneath. The cartilaginous structure includes thyroid and cricoid cartilages, and is homogeneously hypoechoic on US. However, it may be heterogeneous if it contains calcifications.

Hyoid Bone and Vertebrae

The hyoid bone appears as a hyperechoic inverted U-shaped linear structure with posterior acoustic shadowing on the transverse view. Because the thyroglossal duct cyst is located in the region of the hyoid bone, the diagnosis is based on its relationship to the hyoid bone. The pyramidal lobe is located from the isthmus toward the hyoid bone. It can persist after total thyroidectomy and is sometimes misdiagnosed as a recurred tumor.

The vertebrae are anatomical landmarks to locate the cervical and brachial plexus. Therefore, recognizing the bony structures on US images is helpful for identifying and assessing the level of the nerve roots. The absence of the anterior tubercle of the C7 transverse process and prominence of those of the C6 transverse process are used as anatomic landmarks for the identification of the cervical vertebra level. The transverse process of C2–5 can be identified as successive steps cranial to the C6 level. The anterior tubercle of the transverse process can be misdiagnosed as a calcified lymph node; however, it can be easily differentiated by rotating the probe and checking the successive features on longitudinal view. Vertebral injury can occur during CNB for thyroid and neck lesions, and a safe distance should be measured from the needle tip before the procedure.

Thyroid Cartilage and Cricoid Cartilage

The thyroid cartilage has an inverted V shape on the transverse view, and the true and false vocal cords are visible within the structure. The cricoid cartilage has an arch-like appearance on the transverse view, and is located at the level of the C6 vertebra. The posterior surface of its anterior wall is delineated by a bright air-mucosa interface and reverberation artifacts from intraluminal air.

The cricothyroid membrane and thyrohyoid membrane are seen as hyperechoic bands between the caudal and cephalad border of each cartilage. Because the SLN traverses the thyrohyoid membrane and the RLN courses close to the cricothyroid membrane, small remnants of thyroid tissue are retained after thyroid surgery to prevent nerve injury.

Esophagus and Trachea

The trachea is located behind the thyroid gland, and is characterized by alternating hypo- and hyperechoic bands representing cartilaginous rings and annular ligaments on US. The cervical esophagus is usually seen at the left side of the trachea as a multi-layer tubular structure, which presents as an inner hyperechoic mucosa and submucosa layer, middle hypoechoic muscle layer, and an outer hyperechoic adventitial layer. Its location could be easily identified by asking patients to swallow, resulting in peristaltic movement of the esophagus.

The esophagus and trachea can be damaged during minimally invasive treatment such as RF ablation, although this has not yet been reported. The operators should consider the expected ablation zone and strictly trace the tip of the electrode during the ablation of nodules near the esophagus or trachea.

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