EUS of the neck: A comprehensive anatomical reference for the staging of head and neck cancer (with videos)

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ABSTRACT

The use of EUS has application in the nodal staging of head and neck cancer. The technique and the anatomy of head and neck region using EUS have not been described. EUS from three stations in thoracic esophagus, cervical esophagus, and hypopharynx can allow imaging of head and neck. In this article we describe the normal structures from the three stations. The EUS imaging of head and neck can give relevant and additional information in malignancies of head and neck.

Key words: EUS, esophagus, hypopharynx, malignancy, neck

BACKGROUND

Sonographic imaging of the head and neck is often difficult due to the anatomical complexity; hence, computed tomography (CT) and magnetic resonance imaging (MRI) are usually performed as the imaging techniques of the first choice for assessing the extent and nature of the diseases of this region. However, ultrasonography (US) is still an integral part of the routine diagnosis, treatment, and follow-up of diseases of the head and neck. A major advantage of US, apart from being highly sensitive and nonionizing, is that the attending physician gets the “big picture,” when he performs the examination himself. Each malignancy of head and neck has its unique first echelon and pattern of spread to different nodal stations. Although nowadays positron emission tomography-CT (PET-CT) is playing an increasingly important role in the detection of pathologic lymph nodes (LNs); a cytopathological confirmation is possible only by CT- or US-guided fine needle aspiration (FNA). EUS adds value during esophageal and lung cancer staging. Little information is available regarding the use of EUS and...
EUS-FNA aspiration cytology (EUS-FNAC) to stage tumors in the head and neck region.\textsuperscript{[13-15]} No specific probe has been developed for EUS evaluation of the head and neck region.\textsuperscript{[16,17]} EUS with the help of a modified probe has shown results superior to CT and MRI in the assessment of laryngeal cancer.\textsuperscript{[5,3]} A special advantage of EUS examination is that the flexible probes can be used for EUS-FNAC of LNs or masses not accessible to CT or ultrasound.\textsuperscript{[11,12,18]} The aim of this article is to present the techniques and limitations of EUS in the diagnostic evaluation of structures and LNs of the head and neck.

**TECHNIQUES OF IMAGING**

EUS examination of structures of the neck can be done on outpatient basis after conscious sedation using intravenous midazolam and oral xylocaine (10\%) spray. The images in this article were procured with a linear echoendoscope (Pentax EG 3830 UT) using Hitachi Avius-processor. Imaging can be done from three stations: the upper part of thoracic esophagus, the cervical esophagus, and the hypopharynx. The scope is generally unstable near the pharyngoesophageal junction; hence, the examination is started after inserting the echoendoscope into the upper part of thoracic esophagus (Station 1). Subsequent withdrawal is done to cervical esophagus (Station 2), and the last part of the examination is done from hypopharynx (Station 3) [Figures 1, 2 and Videos 1, 2].

**Six home bases**

A home base is a structure, which can be easily found by manipulation of the scope if the orientation is lost during imaging. The six main home base structures that can be identified at three stations are arch of aorta, trachea, sternocleidomastoid muscle, thyroid gland, and the great vessels of the neck.

**The movements**

Imaging of structures is done after the apposition of the probe against the wall. A 360° clockwise or anticlockwise rotation is done to change the axis of imaging. In general, a rotation of the scope done in such a manner that it showed structures posterior, lateral, or anterior to the scope in a sequential manner during rotation [Figures 1a and 2]. For uniform description in this article, the structures are described while doing a clockwise movement after doing a maximum anticlockwise rotation and visualization of spine, which is a structure in posterior relation to the esophagus and pharynx.

**The orientation**

A cranial part of image to the right and caudal part of image to the left convention is followed, and examination is done in three steps [Figure 3a]:

i. Identify home base
ii. Identify anatomic landmarks
iii. Identify LNs.

![Figure 1](image-url)
Station 1: Thoracic esophagus
Identification of home bases
The arch of aorta, the trachea, and the spine. The arch of aorta is easily identified at about 20–22 cm distance in the thoracic esophagus as a circular anechoic vascular structure of 1.5–2.0 cm diameter [Videos 3 and 4]. A clockwise rotation from this position takes the imaging plane anteriorly toward the trachea and anticlockwise rotation from this position takes the imaging plane posteriorly toward the spine. The trachea is identified by the presence of air and cartilage in the wall of the trachea, both of which create prominent artifacts [Station 1, Figure 3b and c].

Identification of anatomic landmarks
Posterior imaging
The spine creates a hyperechoic artifact, and the hypoechoic intervertebral discs are seen between two hyperechoic vertebrae [Figure 3d].

Lateral imaging
On clockwise rotation from the spine, the descending aorta is identified, and the upper margin of the arch of aorta is identified after tracing the descending aorta to the highest point with slight clockwise rotation of the scope.

Anterior imaging
On further clockwise rotation, the origin of the left subclavian artery left common carotid artery, and brachiocephalic trunk can be seen from the upper border of the arch of aorta [Station 1, Figure 4a-d]. The left subclavian artery, which goes close to apex of lung commonly, creates a mirror image artifact. The left common carotid artery runs close to the left wall of the trachea and the brachiocephalic trunk crosses to the right side of the trachea. During the clockwise rotation of the echoendoscope, the imaging axis passes from the left common carotid artery to the trachea, and it is difficult to visualize the brachiocephalic trunk by EUS scope. The left brachiocephalic vein (LBCV) crosses from the left to right side in front of great vessels of neck.

Station 2: Cervical esophagus
Identification of home bases: The great vessels of the neck, the thyroid gland, and the sternocleidomastoid muscle
In this position, an ultrasound probe placed externally from the neck reveals the good quality of images to an ultrasonographer. The scope is in an unstable position for EUS-guided FNAC in this position. The cervical LNs in this position can be also visualized from the neck, and it is generally recommended to do
Once the echoendoscope and the probe are placed inside the cervical esophagus, the great vessels of the neck are easily identified and traced cranially into the carotid sheath within the carotid triangle [Station 2, Figure 5b and Video 5]. The sternocleidomastoid muscle is seen on the far side of the carotid triangle [Station 2, Figure 5c and Video 6]. A clockwise rotation from this position takes the imaging axis sequentially toward the left lobe of the thyroid gland, trachea, and the right lobe of the thyroid gland.
union of LBCV and internal jugular vein marks the lowest boundary of supraclavicular fossa [Station 2, Figure 6a-d and Video 8]. The LBCV is seen to cross in front of the great vessels of the neck [Figure 6a]. The course of left subclavian artery can be followed up till it arches and enters the supraclavicular triangle and the arching part of subclavian artery is easily visualized [Station 2, Figure 6b and Video 9]. Even with EUS, it is occasionally possible to see the brachiocephalic trunk taking origin from the upper part of the arch of aorta and to trace the course till the division into right common carotid and right subclavian artery. Sometimes, it is possible to see the joining of the thoracic duct in the angle between the joining of LBCV and left subclavian vein [Station 2, Figure 6c and Video 5].

Anterior imaging
A clockwise rotation beyond the common carotid artery takes the beam toward the anterior compartment. The visualization of structures anterior to trachea is not possible by EUS.

Identification of nodes
The important group of LNs in this place includes the lower and middle jugular group along the carotid sheath and Level VI LNs in the anterior compartment. Among the Level VI LNs, the LNs lying anterior to trachea cannot be identified, but the LNs in paratracheal region, especially on the left side can be easily identified. When the LNs are classified according to the International Association of Study of Lung Cancer, the identified subgroups are Station 2L, 2R 3a and 3p [Station 2, Figure 6d, Videos 10 and 11].

Station 3: Hypopharynx
Identification of home bases
The thyroid gland, internal jugular vein, and sternocleidomastoid muscle. It is easy to locate the common carotid artery and internal jugular vein within the carotid sheath from the hypopharynx on both sides of the neck. The thyroid cartilage creates an artifact in hypopharynx and the upper part of thyroid gland is seen on either side of thyroid cartilage closely related to common carotid artery. The sternocleidomastoid muscle is occasionally seen beyond the internal jugular vein [Station 3 and Figure 7].

Identification of anatomic landmarks
Posterior imaging
Maximum anticlockwise rotation identifies the spine posteriorly. Slight clockwise rotation identifies the longus colli muscle just adjacent to the posterior pharyngeal wall along with the vertebral artery [Station 3, Figure 8a and b].

Lateral imaging
Further clockwise rotation identifies the sternocleidomastoid muscle and the appearance of structures within the carotid sheath. The common carotid artery is very easily traced upward within the carotid sheath, and sometimes the bifurcation into
external and internal carotid artery can be seen in Station 3, Figure 9a-c. The course of internal jugular vein is easily followed within the carotid sheath. Some part of the internal jugular vein is visualized through the upper part of the left or right lobe of thyroid gland.

**Anterior imaging**
A clockwise rotation beyond the common carotid artery takes the beam toward the anterior compartment. The visualization of structures anterior to trachea is not possible by EUS, and the visualization of pretracheal LNs is not possible. The lobes of thyroid gland and LNs on the either side of the trachea in paratracheal region (paratracheal LNs) can be visualized.

**Identification of nodes**
The important group of LNs in this place includes upper jugular LN station - for head and neck cancer and LNs of Station 2L, 3a and 3p for lung cancer [Station 3 and Figure 10]. No LNs are present posterior to cervical esophagus in the retropharyngeal space.

The Diagnostic US of the head and neck is mainly used to assess organs and lesions that lie near the surface, including the salivary glands, the thyroid gland, the major vessels, enlarged superficial LNs, and other superficial pathologic lesions.[19-22]

Although EUS and EUS-FNA have a well-established role in the assessment and management of gastrointestinal and pulmonary diseases, the data on their value for assessing tumors in the head and neck region are very limited.[23] Traditionally, the mediastinum and lower part of the neck has been evaluated using standard imaging techniques such as CT and MRI. Cervical LN metastases are of overriding importance in predicting the prognosis in these patients.[24] Size has been used as one of the criteria for differentiating benign from malignant LNs. LNs larger than 10 mm in size are considered abnormal but even smaller LNs may harbor metastasis.[25] CT and MRI have suboptimal sensitivity for detecting the smaller size of LNs and patients with false-negative imaging on CT or MRI are generally never referred for EUS. The decision regarding the presence of metastasis in such smaller group of LNs is of importance and EUS-FNA offers a chance to establish the presence of pathology. A comparison of ultrasound and PET/CT for staging and surveillance of head and neck and thyroid cancer found superior sensitivity (96.8% vs. 90.3%), specificity (93.3% vs. 20%), positive predictive value (96% vs. 70%), and negative predictive value (93% vs. 50%) for ultrasound compared

![Figure 7. The thyroid gland is seen. The internal jugular vein is seen in the carotid sheath beyond the thyroid gland. With slight rotation, the common carotid artery and sternocleidomastoid muscle can be seen, however, they are not seen in this figure. LIJV: Left internal jugular vein](image)

![Figure 8. (a and b) The vertebral artery is seen in the areas between the two adjacent transverse processes of vertebrae. The longus colli muscle is seen between the probe and the vertebral artery. The transverse processes interrupt the visualization of the entire course of artery](image)

![Figure 9. (a) In this case, the external carotid artery is seen with a long parallel course to the wall of pharynx. In the upper most part, the external carotid artery is seen going away from the transducer. (b) The branch of the external carotid artery is seen going away from the probe in esophagus. It can be either the superior thyroid, facial, or lingual artery. (c) The internal carotid artery is more medial and more posterior to external carotid artery and has no branch. It curves away from the pharynx and enters the base of skull](image)
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