Ultrasound anatomy of the neck: The infrahyoid region

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KEYWORDS

Ultrasound;
Anatomy;
Neck.

Abstract The infrahyoid region of the neck includes the visceral, anterior cervical, posterior cervical, carotid, retropharyngeal, and perivertebral spaces. The visceral space contains the thyroid, parathyroid glands, larynx, hypopharynx, the cervical trachea, and esophagus, the recurrent laryngeal nerve. The carotid space contains two parts, which extend from the skull base to the aortic arch and are delimited by the three layers of the deep cervical fascia (superficial, middle, and deep). It contains the internal carotid artery, the internal jugular vein, cranial nerves (IX–XII), the sympathetic plexus (suprahyoid compartment), the common carotid artery, the internal jugular vein, vagus nerve (infrahyoid compartment). The retropharyngeal space is a midlinespace containing adipose tissue that extends from the skull base to the upper mediastinum. It is located posterior to the pharynx and cervical esophagus, anterior to the danger area and the perivertebral space.

The perivertebral space extends from the skull base to the clavicles and includes two parts: prevertebral and paraspinal. The prevertebral space includes the prevertebral muscles (long muscles of the neck and head), the scalene muscles (anterior, middle, and posterior), the roots of the brachial plexus, the phrenic nerve, the vertebral arteries and veins, and the vertebral bodies. The paraspinal space contains the paraspinal muscles and the posterior elements of the cervical spine.

The posterior cervical space is a deep space located posterior to the sternocleidomastoid muscle. It contains the accessory nerve, the accessory chain lymph nodes, the pre-axillary component of the brachial plexus, and the dorsal scapular nerve. The anterior cervical space is located deep to the strap muscles and sternocleidomastoid muscle. It surrounds the front and sides of the visceral space and is related posteriorly to the carotid space. This article reviews the ultrasound features of the structures located in the infrahyoid region of the neck.

Sommario Gli spazi viscerale, cervicale anteriore, cervicale posteriore, carotideo, retrofaringeo e perivertebrale, localizzati al di sotto dell'osso ioide, costituiscono la regione infraioide.

Lo spazio viscerale contiene tiroide, paratiroidi, linfonodi, laringe, ipofaringe, il tratto cervicale della trachea e dell'esofago, il nervo laringeo ricorrente.

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Lo spazio carotideo è costituito da due parti che si estendono dalla base cranica all'arco aortico, delimitati dai tre strati della fascia cervicale profonda (foglietti superficiale, medio e profondo). Contiene: arteria carotide interna, vena giugulare interna, nervi cranici (9–12), plesso simpatico (collo sopraioideo), arteria carotide comune, vena giugulare interna, nervo vago (collo sottoioideo).

Lo spazio retrofaringeo è uno spazio adiposo mediano che si estende dalla base cranica al mediastino superiore, localizzato posteriormente alla faringe e all'esofago cervicale, anteriormente allo spazio pericoloso e allo spazio perivertebrale.

Lo spazio perivertebrale è esteso dalla base cranica alle clavicole, comprende due parti: prevertebrale e paraspinale. Lo spazio prevertebrale comprende i muscoli prevertebrali (lunghi del collo e della testa), i muscoli scaleni (anteriore, medio e posteriore), le radici del plesso brachiale, il nervo frenico, le arterie e vene vertebrali, i somi vertebrali. Lo spazio paraspinale comprende i muscoli paraspinali e le costituenti posteriori del rachide cervicale.

Lo spazio cervicale posteriore è uno spazio adiposo situato in profondità e posteriormente al muscolo sternocleidomastoideo; contiene il nervo accessorio, linfonodi della catena accessoria, la componente pre-ascellare del plesso brachiale e il nervo scapolare dorsale.

Lo spazio cervicale anteriore è uno spazio adiposo situato in profondità ai muscoli sottoioidei ed al muscolo sternocleidomastoideo; circonda anteriormente e sui lati lo spazio viscerale, posteriormente ha rapporti con lo spazio carotideo.

Nell'articolo vengono presentati gli aspetti ecografici delle strutture situate nella regione infraioidea del collo.

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Introduction

The infrahyoid region of the neck is located below the hyoid bone and contains the visceral, anterior cervical, posterior cervical, carotid, retropharyngeal, and perivertebral spaces. Some of these spaces are confined to the infrahyoid region; others continue into the suprahyoid region of the neck and the mediastinum.

Visceral space

The visceral space is a cylindrical space bounded by the middle layer of the deep cervical fascia, which extends from the hyoid bone to the upper mediastinum. It is delimited anterolaterally by the anterior cervical space, posterolaterally by the carotid space, and posteriorly by the retropharyngeal space [1,2]. It includes the thyroid and parathyroid glands, the larynx, the hypopharynx, the cervical segments of the trachea and esophagus, and the recurrent laryngeal nerve.

The **thyroid gland** is composed of two lobes connected by a median isthmus (which may be absent in some cases); 40% of all patients have an accessory lobe—the pyramidal lobe, which is more or less developed. It extends from the isthmus toward the hyoid bone, in front of the thyroid cartilage (Fig. 1) [3]. The thyroid lies in front of and on the sides of the trachea. It is bounded posterolaterally by the carotid space, and its anterior and lateral aspects are covered by the strap muscles and the sternocleidomastoid muscles. Its posteromedial border is near the tracheoesophageal groove, which contains the recurrent laryngeal nerve, the parathyroid glands, and lymph nodes (Fig. 3A and 4) [1,2].

The posterior surfaces of the lobes are adjacent to the perivertebral space and on the left to the esophagus. The blood supply is provided by the superior thyroid artery (the first anterior branch of the external carotid artery),

the inferior thyroid artery (a branch of the thyrocervical trunk, which originates from the subclavian artery), and in rare cases (3%) also by the thyroid ima artery (branch of the anonymous artery or of the aortic arch) [3]. The area is drained by three veins: the upper and middle veins empty into the internal jugular vein, and the lower one drains into the brachiocephalic vein [3]. Lymphatic drainage occurs primarily through the prelaryngeal, pretracheal, and paratracheal lymph nodes (level 6, the paratracheal nodes along the recurrent laryngeal nerve also drain the mediastinum). Drainage is also provided laterally by the internal jugular (levels 2–4) and the accessory chains (level 5) and, in the

Fig. 1 Axial scan at the level of the thyroid showing the right lobe (1), isthmus (2) and left lobe (3) of the thyroid, the trachea (4), esophagus (5), common carotid artery (6), internal jugular vein (7), the sternocleidomastoid (8), sternohyoid (11), long cervical muscles (12), and the cervical vertebrae (13).

Fig. 2 Axial scan cranial to the thyroid isthmus showing the sternothyroid (10), sternohyoid (11), and thyrohyoid muscles (18), the larynx (16), and the hypopharynx (17).

suprahyoid portion of the neck, along the internal jugular vein [3]. During embryogenesis, the thyroid descends from the foramen cecum (base of the tongue) along the thyroglossal duct, which runs in front of the hyoid bone and laryngeal cartilage [3]. The gland is characterized by fine, uniform internal echoes, hyperechogenicity with respect to the surrounding muscles, and a thin hyperechoic capsule (Fig. 1,3A, 4). With advancing age, the thyroid frequently undergoes fibrosis and/or calcification manifested by the presence of hyperechoic linear or ring-shaped streaks [4,5].

There are usually four **parathyroid glands**, two upper and two lower. They are generally located in the visceral space posterior to the thyroid, adjacent to the tracheoesophageal groove. The presence of supernumerary glands, up to 12, is common. Fewer than 2% of the ectopic glands are superior parathyroids; they are located behind the pharynx or esophagus. Approximately 50% are inferior parathyroids, and 15% of these are located within 1 cm from the lower pole of the thyroid. In 35% of the cases, the ectopic gland is located anywhere from the angle of the jaw

to the anterior mediastinum. The most common sites are right below the lower pole of the thyroid or thymus; retropharyngeal–retroesophageal and posterior mediastinal locations are rarer [1–3]. The superior parathyroids are vascularized by the superior thyroid artery; the inferior glands by the inferior thyroid artery. Under physiological conditions, the parathyroid glands cannot be assessed by ultrasound [4,5].

The **trachea** extends from the larynx (which lies approximately at the level of the sixth cervical vertebra) to the carina (fifth dorsal vertebra). It is composed of cartilaginous rings anterolaterally and posteriorly by a fibromuscular membrane [3]. Anteriorly, the trachea has relations with the strap muscles and the isthmus of the thyroid (at the level of the II–IV cartilaginous rings). On either side are the lobes of the thyroid and the structures found in the tracheoesophageal groove (recurrent laryngeal nerve, parathyroids, lymph nodes), and behind it lies the esophagus (Fig. 1,2,5) [1,2]. The cervical trachea is vascularized by the inferior thyroid artery and drained by the pretracheal and paratracheal lymph nodes (level VI) [3]. Sonographically the trachea is characterized by alternating hypo- and hyperechoic bands representing the cartilaginous rings and annular ligaments, respectively (Fig. 5) [4,5].

The **esophagus** extends from the hypopharynx (at the level of the sixth cervical vertebra) to the abdomen (at the eleventh dorsal vertebra). It lies behind the thyroid and trachea and in front of the last cervical and first few dorsal vertebrae. The cervical segment is shifted somewhat to the left of the midline. The anterolateral walls are adjacent to the structures of the tracheoesophageal groove and the thyroid. On either side are the carotid spaces, and behind are the retropharyngeal and perivertebral spaces (Fig. 1,4A) [1,2]. The cervical esophagus is vascularized by the inferior thyroid artery and drained by the paratracheal lymph nodes (level VI) [3]. On ultrasound, the esophagus has a stratified appearance. The innermost of the three layers is hyperechoic and corresponds to the mucosa and submucosa; the middle layer, hypoechoic, is the muscle layer (which constitutes about 50% of the thickness); and the outer adventitial layer is hyperechoic. The lumen is virtual and is visualized as a thin hyperechoic line (Fig. 4A) [4,5].

Fig. 3 A. Axial scans of the lateral cervical spaces showing A: the left lobe of the thyroid (3), the common carotid artery (6), internal jugular vein (7), the sternocleidomastoid (8), omohyoid (9) and sternothyroid (10) muscles. B. The common carotid artery (6), the sternocleidomastoid muscle (8), the omohyoid muscle (9), the long muscle of the neck (12), the scalene muscles (14), and the vertebral artery (15).

Fig. 4 A Longitudinal scan of the thyroid lobes A: the left thyroid lobe (3), esophagus (5), sternothyroid muscle (10), and cervical vertebrae (13). B The right thyroid lobe (1) and the long muscle of the neck (12).

Carotid space

The carotid space consists of two cylindrical areas that extend from the base of the skull (jugular foramen-carotid canal) to the aortic arch (supra- and infrahyoid portions of the neck and the mediastinum). It is delimited by the three layers of the deep cervical fascia (superficial, medial, deep). It contains the internal carotid artery, internal jugular vein, cranial nerves (IX–XII), sympathetic plexus, supra- and infrahyoid cervical lymph nodes, the common carotid artery, and the vagus nerve (Fig. 1 and 3) [1,2]. In the suprahyoid region of the neck, the carotid space is surrounded by the retropharyngeal space (medially), the perivertebral space (posteriorly), the parotid space (laterally), and the parapharyngeal space (anteriorly).

In the infrahyoid neck, it is surrounded by the anterior cervical space (anteriorly), by the visceral and retropharyngeal spaces (medially), and by the perivertebral and posterior cervical spaces (posteriorly) [1,2].

The right common carotid artery originates from the brachiocephalic trunk, behind the joint sternoclavicular joint. The left common carotid artery originates directly from the aortic arch.

Both ascend within the neck to the upper edge of the thyroid cartilage of the larynx, where each divides to form an internal and external carotid artery. Each of the common carotids presents a dilatation at the bifurcation, the carotid sinus, which usually extends into the initial segment of the internal carotid artery. The common carotids run behind the sternocleidomastoid muscles and medial to the internal jugular veins. About halfway up the neck, they intersect the superior bellies of the omohyoid muscles. The vagus nerves run behind the two vessels [3].

Fig. 5 Longitudinal scan at the level of the trachea shows the trachea (4), the isthmus of the thyroid (2), the sternohyoid muscle (11), and the larynx (16).

The internal jugular veins originate from the jugular foramen at the base of the skull (as direct continuations of the transverse sinuses). They descend within the neck along the lateral wall of the pharynx, posterior to the internal carotid artery, continue laterally to the common carotid, beneath the sternocleidomastoid muscle, and finally merge with the subclavian veins, forming the brachiocephalic venous trunks [3].

Retropharyngeal space

The retropharyngeal space is a midline area of adipose tissue extending from the skull base to the upper mediastinum. It is located posterior to the pharynx and cervical esophagus, anterior to the danger space and the perivertebral space (Fig. 1,2) [1,2]. The suprahyoid part contains lymph nodes, which are absent in the infrahyoid portion of this space.

The danger space, which is located between the retropharyngeal and perivertebral spaces, is an area containing adipose tissue. Its name reflects the fact that it provides a route for the diffusion of inflammatory or neoplastic lesions from the retropharyngeal space to the posterior mediastinum [1].

The perivertebral space

The perivertebral space extends from the skull base to the clavicles and includes prevertebral and paraspinal portions. The prevertebral space is located posterior to the pharynx and cervical esophagus. Anterolaterally, it is related to the carotid space and laterally to the anterior portion of the posterior cervical space. It contains the prevertebral muscles (long muscles of the head and neck), the scalene muscles (anterior, middle, and posterior), the roots of the brachial plexus, the phrenic nerve, the vertebral arteries and veins, and the bodies and pedicles of the vertebrae (Fig. 1,3,4). The paraspinal space is surrounded on the sides by the posterior cervical space. It lies posterior to the transverse processes and lateral to the posterior arches and the spinous processes of the cervical vertebrae and contains the paraspinal muscles and posterior components of the cervical spine [1,2,6].

Posterior cervical space

The posterior cervical space is an adipose-tissue space located deep and posterior to the sternocleidomastoid

muscle. Anteriorly, it is related to the carotid space. It surrounds the sides of the perivertebral space and contains the accessory nerve (XI cranial nerve), accessory chain lymph nodes (level 5), the pre-axillary component of the brachial plexus, and the dorsal scapular nerve [1,6].

Anterior cervical area

The anterior cervical space is located deep to the sternocleidomastoid muscle and infrahyoid muscles. It surrounds the front and sides of the visceral space and posteriorly it is related to the carotid space [1].

The strap muscles are arranged in a superficial layer (sternohyoid and omohyoid muscles) and a deep layer (sternothyroid and thyrohyoid). They are surrounded by the superficial layer of the deep cervical fascia, which also envelops on the sides the sternocleidomastoid muscle (Fig. 1,2) [3].

Between the strap muscles and the subcutaneous tissue lies the platysma muscle.

Conclusions

Various diseases can affect the infrahyoid neck region, and imaging studies, particularly ultrasound, are becoming

increasingly important for a correct diagnosis and treatment. For this reason, a thorough knowledge of the anatomy of this region is essential for the completeness of the examination.

Conflict of interest statement

The authors have no conflict of interest.

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