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Computed Tomography of the Cervical Lymph Nodes: Use of Intravenous Contrast Enhancement

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Intravenous contrast administration increases the sensitivity of computed tomographic scanning for enlarged cervical lymph nodes but requires a detailed knowledge of neck anatomy, especially in order to distinguish certain normal vessels from involved nodal groups. Along the *collar* chain, relations between the parotid and submandibular salivary glands and the posterior and anterior facial veins and facial artery are analyzed. The digastric muscle is defined as a transitional landmark between collar and deep cervical nodes. Along the *deep cervical* chain, emphasis is on the internal jugular vein, its variability in size, and its relations to the anterior scalene and omohyoid muscles.

This is a preliminary report of our experience with computed tomographic (CT) scans of the neck using intravenous contrast material for vascular opacification. Our aim has been to define the appearances of normal anatomic structures to allow more confident recognition of cervical lymph node enlargement.

Materials and Methods

We divide the neck into two main zones, upper and lower, corresponding to chains of *collar* and *deep cervical* nodes (fig. 1). The upper zone of *collar* nodes is subdivided into a superior region related to the parotid gland and an inferior region related to the submandibular gland. The lower zone is subdivided into a superior region, between the hyoid bone and the glottis, and an inferior region, between the glottis and the sternal notch. So from top to bottom, there are four regions: parotid, submandibular, supraglottic, and infraglottic.

The two layers of the *deep cervical* fascia are particularly important in cases of cervical lymphadenopathy. The superficial layer invests the parotid and submandibular glands and envelops the sternocleidomastoid and digastric muscles. As such, it forms the floor of the digastric (or submaxillary) triangle and the roof of the posterior triangle. The deep layer forms the floor of the posterior triangle deep to the sternocleidomastoid muscle.

We reviewed 25 high-resolution CT scans of the neck, obtained with a Pfizer 0450 scanner, with intravenous iodinated contrast material administered by bolus and/or drip infusion. Ten of these had cervical lymphadenopathy. Scans were obtained in the axial projection, with 5-mm-thick slices spaced 5 mm apart, from the external auditory canals to T1.

Observations

Collar Nodes

This chain extends along the base of the skull from suboccipital to submental regions [1], but the areas of greatest clinical and radiologic interest are related to the parotid and submandibular glands (fig. 2). The parotid region contains preauricular and infraparotid nodes, while the submandibular region contains submaxillary nodes [1].

Parotid region. The parotid gland is a fibrofatty gland on CT, lying in a bony recess formed by the temporomandibular joint and condylar process of the mandible anteriorly, the external auditory canal superiorly, and the mastoid process posteriorly. The medial margin of the recess is marked by the styloid process and the tip of the transverse process of the atlas, and is filled by the posterior belly of the digastric and the stylohyoid muscles [2]. The parotid is invested by the "superficial fascia" (subcutaneous tissue and platysma) of the neck laterally and a continuation of the superficial layer of the deep cervical fascia from the masseter muscle medially [2].

A prominent feature on axial CT of the parotid gland with contrast material is a medial density due to the posterior facial vein [3]. This vein descends deep relative to the parotid initially, but then enters the gland where it can be found at lower levels (fig. 2). Here it is important for two reasons: because it can be confused, without contrast material, for an enlarged intraparotid lymph node, and because it marks, for the surgeon, the level of the facial nerve within the gland [2]. As it emerges from the lower pole of the parotid, the posterior facial vein drains via two stems, posteriorly to the external jugular vein, and anteriorly, with the anterior facial vein, to join the internal jugular vein [2].

The posterior facial and external jugular veins are superficial to the digastric and stylohyoid muscles. The internal jugular vein is deep relative to these muscles and to the styloid process. The internal carotid artery is anteromedial to the jugular vein.

The preauricular lymph nodes lie immediately around and within the parotid gland, along the course of the facial nerve [1], so that the gland can be displaced or permeated by enlarged nodes. In the latter case, its density may increase as fatty tissue is replaced by nodes.

Submandibular region. The digastric triangle is bounded inferiorly by the anterior and posterior bellies of the digastric muscle, superiorly by the ramus of the mandible, and medially mainly by the

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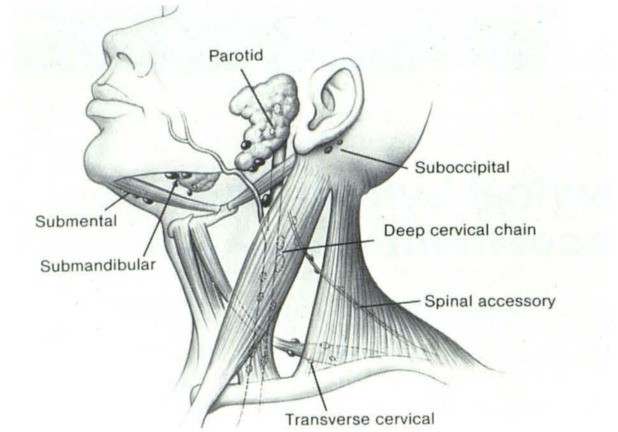


Fig. 1.—Cervical lymph nodes. Suprahyoid nodes form collar around base of skull. Note groups related to parotid and submandibular salivary glands. Infrahyoid nodes form a triangle in lateral neck. Deep cervical chain accompanies internal jugular vein. (Drawing by R. J. Demarest.)

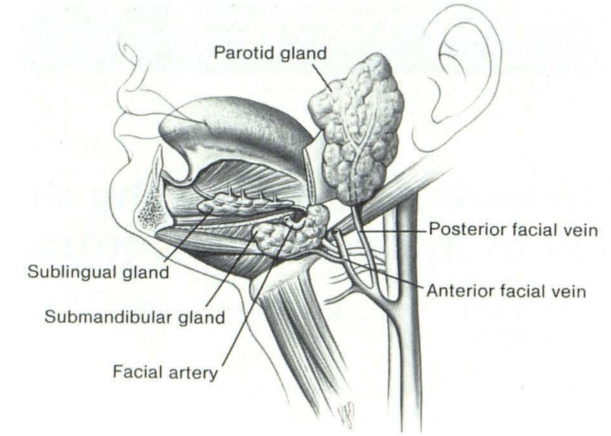
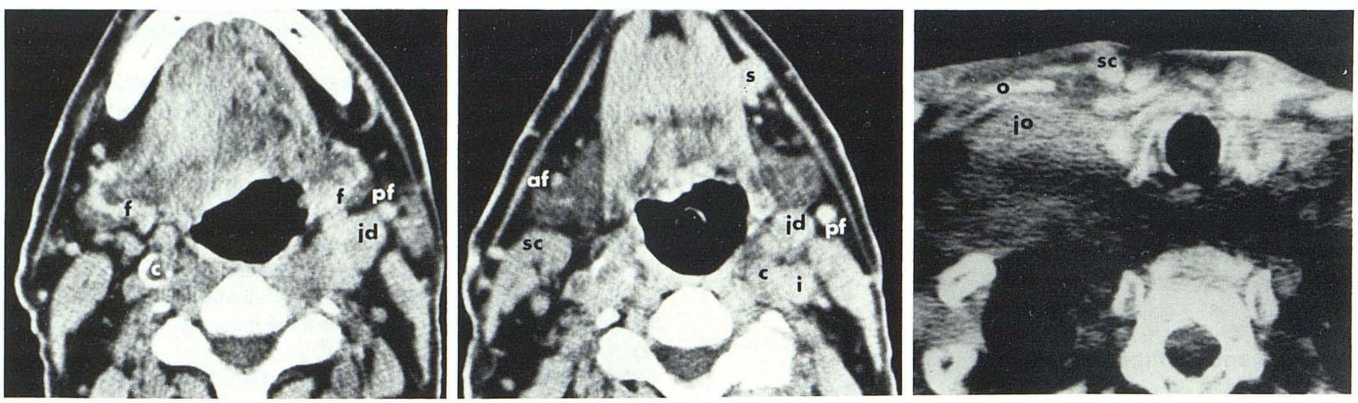


Fig. 2.—Vascular relations of major salivary glands. Posterior facial vein lies within lower pole of parotid gland and marks position of facial nerve. Anterior facial vein is superficial and inferior to submandibular gland; facial artery is deep and superior to it. (Drawing by R. J. Demarest.)



A B C

Fig. 3.—Tongue cancer with multiple enlarged lymph nodes. **A**, Tongue is asymmetrically enlarged with displacement of midline septum to left. Facial arteries (f) pass over slightly lucent submandibular glands, especially on right, and under mandibular ramus on left. Carotid artery calcification (c) on right, and enlarged jugulodigastric node (jd) just lateral to this vessel on left. Adjacent to inferior pole of parotid gland is posterior facial vein (pf). **B**, Lower view. Enlarged anterior submandibular node (s) contralateral to tongue primary. Enlarged jugulodigastric node (jd) is again seen anterior to common carotid artery (c) and internal jugular vein (i). Anterior (af) and posterior (pf) facial veins are lateral and posterior, respectively, to right and left submandibular glands. Right sternocleidomastoid muscle (sc) is laterally displaced by large deep cervical node at lower level. **C**, Much lower view. Massive juguloomohyoid node (jo) displaces omohyoid muscle (o) anteriorly. Sternocleidomastoid tendons (sc) insert on clavicles. Image artifact due to thickness of shoulders. "Skip" involvement of juguloomohyoid node is an unusual but well known pattern of metastatic spread of tongue cancer [1].

mylohyoid muscle. The digastric triangle is covered superficially by subcutaneous tissue and platysma muscle. The submandibular gland is enveloped by a split superficial layer of deep cervical fascia [2]. On axial CT, the submandibular gland is a slightly lucent disk of soft tissue, flattened on its medial aspect by the tongue.

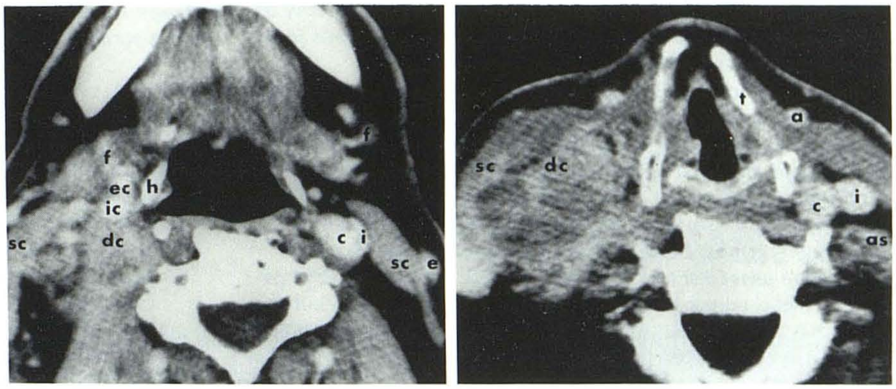
After contrast administration, enhancement can sometimes be seen superficially at the inferior aspect of the gland. This is the anterior facial vein (figs. 2 and 3B), which descends from the mandibular ramus inferiorly, superficially, and posteriorly over the submandibular gland to join the posterior facial vein and drain into the internal jugular system [2].

The facial artery can often be seen forming a linearly enhancing curve over the superior aspect of the submandibular gland (figs. 2 and 3A). It has a deeper course than the anterior facial vein. It courses superiorly and anteriorly, deep relative to the posterior belly of the digastric and stylohyoid muscles and therefore to the submandibular gland [2]. It then passes superolaterally over or through the superior margin of the submandibular gland to reach the inferior margin of the mandibular ramus.

The submaxillary lymph nodes are located in front of, within, and behind the submandibular gland (figs. 1 and 3B). They are said to be most numerous about the facial artery and anterior facial vein [2]. We have more often seen enlargement of a node at the lower pole of the gland near the anterior facial vein. Both benign and malignant lymphadenopathy occur here, but we have been unable to distinguish them. A malignant node, however, may show central lucency, suggestive of necrosis, and rim enhancement, which could represent a pseudocapsule of compressed, normally vascular tissue.

Deep Cervical Nodes

Below the submandibular region, the shape of the neck is more regularly tubular. The deep cervical nodes have the greatest clinical



A B

Fig. 4.—Metastatic squamous cell carcinoma, primary unknown, in large deep cervical chain node. **A**, Sternocleidomastoid muscle (sc) is laterally displaced by large mass at lower cervical level. Superior tip of mass (dc) compresses and displaces internal (ic) and external (ec) carotid arteries. Facial artery (f) passes over submandibular gland on right and under mandibular ramus on left. Carotid bifurcation (c) and comma-shaped internal jugular (i) are in their normal positions on left. External jugular vein (e) is lateral to sternocleidomastoid muscle (sc). Superior cornua of hyoid bone (h) are medial to carotid bifurcations. **B**, Huge necrotic deep cervical node (dc) markedly displaces sternocleidomastoid muscle (sc). Common carotid artery (c) and internal jugular vein (i) are in normal position on left but are compressed and displaced on right. Consequently, anterior jugular veins (a) are conspicuous. Margins of thyroid cartilage are normally irregular. Anterior scalene muscle (as) originates from transverse process of cervical vertebra at anterior margin of prevertebral musculature on left.

importance here (figs. 1, 3, and 4). This chain closely accompanies the internal jugular vein, whose position with respect to the common carotid artery, seen distinctly after contrast injection, changes slowly from posterolateral to anterolateral, as it descends from supraglottic to infraglottic regions. The largest superficial muscle at these levels, the sternocleidomastoid, shows an analogous shift in position from lateral to anterior. A small chain of lymph nodes parallels the spinal accessory nerve [1], but we have not seen involvement of these nodes by adenopathy on CT.

Supraglottic region. The calcific landmarks in this region are the hyoid bone and thyroid cartilage. The submandibular gland and its associated nodes may overlap with the level of the superior cornua of the hyoid, especially in cases of lymphadenopathy, but it is useful to consider the supraglottic region separately as it is somewhat distinct, pathologically as well as anatomically. Many of the metastatic nodes at this level are related to invasive tumors of the supraglottic larynx and hypopharynx [4]. There is also, however, overlap with enlarged "jugulodigastric" nodes from more remote tongue or jaw primaries [5].

The hyoid bone is seen at upper supraglottic levels. The bifurcation of the common carotid artery is often seen adjacent to it and may be calcified.

At lower supraglottic levels, the thyroid cartilage is seen and, anterior to it, the strap muscles, a thin transverse band of soft tissue. The most lateral of these muscles is the omohyoid, which will be described in more detail in the subsequent section.

One difficulty in this region is the normal irregularity of the superior margin of the thyroid cartilage. When a tumor is adjacent to it, the evaluation of erosion through cartilage may require closely spaced cuts.

The deep cervical chain of nodes follows the internal jugular vein so, after contrast administration, lymphadenopathy can often be seen against the lucent (fatty connective) tissue surrounding the common carotid artery and internal jugular vein. Separation of cervical muscle layers by the deep cervical fascia, in particular, contributes to the visibility of enlarged deep cervical nodes on CT. The sternocleidomastoid muscle is ensheathed by the superifical layer, while the paravertebral muscles, the most anterior of which are the anterior scalenes, are covered by the deep, or prevertebral, layer. These layers are usually maintained despite the presence of multiple enlarged nodes. In such cases, the separation of superficial and deep layers may actually be exaggerated by the mass that, whether it is benign or malignant, further separates, rather than penetrates, them. Consequently, the intervening layer of lucent (fatty connective) tissue just above the mass may widen (fig. 4A). Enlarged deep cervical nodes may also be more apparent because of the paucity of confusing branch vessels at the supraglottic level; also, because of the thickness of the overlying sternocleidomastoid, the nodes tend to be discovered at a later, and larger, stage.

At supraglottic levels, the internal jugular vein is normally directly lateral to the common carotid artery and may be very asymmetric. When a mass obstructs one internal jugular, or previous surgery has sacrificed it, the *opposite* internal jugular may become unusually large. In such cases, the *anterior* jugular veins may be conspicuous anterior to the strap muscles at supraglottic levels. These are usually symmetric (fig. 4B) and, after administration of a contrast agent, should not be confused with enlarged nodes of an anterior cervical group.

Infraglottic region. The calcific landmarks in this region are the cricoid and thyroid cartilages and the trachea. The main soft-tissue feature is the thyroid masses on either side of the trachea. These are usually apparent on CT because of their size, symmetry, and increased density.

The internal jugular veins move from a lateral to an anterolateral position, with respect to the common carotid arteries, at infraglottic levels. The common carotids indent the posteromedial aspect of the thyroid. The vertebral arteries can sometimes be seen entering the spine. The anterior jugular veins, when seen at supraglottic levels, may continue to descend anterior to the thyroid glands.

Normal vessels in the infraglottic region can, more often than in the supraglottic region, be confused with adenopathy of the deep cervical chain. In particular, the internal jugular vein can become very large at lower levels, particularly where the internal jugular and subclavian veins form the brachiocephalic vein. The potential for confusion is complicated by the frequency of poor visualization of the cervical soft tissues at these low levels due to artifacts produced by the shoulders. The difficulty is compounded when the patient has had a radical neck dissection on the opposite side. The administration of a contrast agent is often helpful in such cases.

As each anterior scalene muscle moves more anteriorly in the lower neck toward its insertion on the first rib, it separates more widely from the other prevertebral muscles. It is, however, usually symmetric and should not be confused with a mass.

The omohyoid muscle moves laterally, away from the other strap muscles, at about the level of the thyroid. It crosses anterior to the internal jugular vein at a level that is not infrequently involved by metastases to the deep cervical chain, and consequently it may be anteriorly displaced by an enlarged "juguloomohyoid" node [4] of this chain (fig. 1C).

At the lowest levels of the neck, the inferior belly of the omohyoid can sometimes be seen directed posteriorly toward its insertion on the scapula. Medial to it, the more massive insertion of the levator scapulae can often be seen. These muscle insertions have elongated shapes that are not likely to be confused with adenopathy of, for example, the transverse cervical ("supraclavicular") nodes [1], which extend laterally at the lowest infraglottic levels.

There are fewer visceral nodes close to the trachea [1]. Enlargement of these nodes has been infrequent in our series, but the impression of a normal esophagus on the posterior wall of the trachea can be mistaken for lymphadenopathy.

A detailed knowledge of neck anatomy is required for early detection of enlarged cervical lymph nodes on contrast-enhanced CT. A familiarity with variations in the normal appearance of the cartilages, salivary glands, muscles, and fasciae is helpful. Particular attention to vascular anatomy is essential because of variants and the close relations of certain vessels to the involved nodal chains. Intravenous contrast enhancement is very helpful in defining these variants and relations.

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