Suprahyoid Head & Neck Tumors

Blake A. Johnson

Advances in surgical techniques for head and neck neoplasms mandate that imagers be familiar with the compartmental anatomy of the head and neck. They must also be familiar with the various forms of pathology that may affect this important region. The cervical fascia divides the soft tissues subjacent to the cranial vault into compartments, within which pathologic processes (especially neoplasms and infections) may spread without resistance. Knowledge of the structures inherent to these compartments provides the imager with an accurate basis for generating a differential diagnosis for a lesion occupying one of these spaces. Tumors may expand to involve adjacent spaces, and some types of lesions typically span several compartments.

In this section, we will review the anatomic and imaging features of the head and neck.

Common head and neck neoplasms, as well as some uncommon lesions will also be discussed.

IMAGING TECHNIQUES

Computed tomography (CT) continues to be an important modality for evaluating the head and neck structures. Fat interposed between muscle and other soft tissues provides excellent contrast in most patients. CT exploits this natural contrast, and does an excellent job of defining lymph nodes. CT also characterized nodes with regard to the presence or absence of central necrosis. Despite these features, magnetic resonance imaging (MRI) is the imaging modality of choice for most lesions in the head and neck. MRI provides unique advantages, including lack of ionizing radiation, superior soft tissue contrast, multiplanar capabilities (without repositioning or reformatting) and characterization of flow. Disadvantages of MR include longer acquisition times. This is frequently problematic in head and neck tumor patients who may have difficulty with control of secretions while lying supine for an extended period of time. Fast techniques partially alleviate this problem. T2-weighted fast spin echo (FSE) images drastically reduce imaging time, which minimizes motion artifact, while providing high resolution images. The conspicuity of lymph nodes and some primary tumors on fat suppressed fast spin echo images is often superior to enhanced T1 weighted sequences. Some lesions, such as neurofibromas, are more conspicuous on the enhanced T1 weighted sequences. Fat suppressed T2 weighted fast spin echo and post contrast T1 weighted sequences improved the detection and delineation of head and neck tumors, especially when used in combination. Enhanced images are invaluable for detecting perineural spread of malignant disease. This is particularly important in cases of squamous cell carcinoma, adenoid cystic carcinoma, lymphomas, minor salivary gland tumors and other sarcomas, which have a high proclivity for perineural infiltration. Favored routes of spread include the second and third divisions of the fifth cranial nerve and the facial nerve. A coronal enhanced sequence employing fat saturation technique provides excellent images for evaluation perineural spread. Thin section (3 mm or less) imaging to interrogate the anatomy of interest provides the requisite sensitivity for detecting pathology. Multiple planes allow for spatial mapping of a lesion and assessment for involvement of adjacent structures. T1-weighted sagittal and T2-weighted fat-suppressed FSE axial and coronal images provide a basic study. If gadolinium is administered, additional sequences may include pre- and post-contrast T1-weighted axial, and post-contrast coronal (with fat-saturation) images.

Currently, high performance gradients are available, allowing even faster acquisition times. Widespread use of gradients strengths up to 27 milliTesla / meter will occur over the next decade. They are currently available in the Siemens *Vision,* General Electric *Echo Speed,* Philips *ACS-NT* and the Picker *Edge* systems. Echo planar images may be obtained in seconds, which alleviates image degradation due to motion. Even patients who are unable to suppress swallowing or moving for extended periods of time while assuming the supine position can be imaged with this technique. Ultrafast imaging capabilities also decrease the need for sedation in pediatric patients.

Proton MR spectroscopy may provide additional specificity when evaluating for recurrent tumor and/or differentiating carcinoma from adjacent uninvolved muscle. This technique provides a noninvasive means for interrogating the metabolic components of the soft tissues of the neck. Clinical trials are required to evaluate the specificity afforded by this promising modality for the evaluation of benign and malignant tumors of the extracranial head and neck.

The MR signal characteristics of extracranial head and neck neoplasms, in addition to the architectural features assessed in multiple planes, provide information which increases specificity over CT. Nonetheless, because the imaging appearance for many of the lesions encountered in the head and neck may be nonspecific, clinical information provides important input for generating an accurate differential diagnosis. Consideration of patient age, clinical findings, and duration of symptoms is important for the imager as well as the clinician.

COMPARTMENTAL ANATOMY

The three layers of the deep cervical fascia form partitions which define anatomic spaces and contain structures of the vascular, lymphatic, and aerodigestive systems. The superficial, middle, and deep layers which define the suprahyoid compartments provide useful anatomic landmarks for accessing pathologic changes. These include the prevertebral, retropharyngeal, carotid, parotid, masticator, parapharyngeal, and the pharyngeal mucosal spaces. The contents of these compartments of the head and neck are summarized in Table 1.

Pathologic processes which arise in one of these compartments will expand within it before violating the fascial boundary and extending into the adjacent space or the skull base. An expanding lesion will also distort and/or displace the adjacent compartments in a predictable fashion, which provides the imager with information regarding the site of origin. An important, and easily recognized, compartment to assess for displacement is the parapharyngeal space. Most lesions involving this space invade it from the adjacent compartment. Fat within this compartment provides excellent contrast with the adjacent soft tissues on computed tomography and magnetic resonance imaging The manner in which this space is displaced renders information regarding the lesion site of origin of the offending lesion.

PATHOLOGY

The type of lesions which arrive in the deep spaces of the head and neck are predictably determined by the structures which normally reside within them. Localization of the site of origin of a mass is thus a vital component of the imaging assessment. The compartment

Table 1: Contents of the deep spaces of the head and neck

COMPARTMENT	CONTENTS
Pharyngeal mucosal space	Mucosa Constrictor muscles Lymphoid tissue Minor salivary glands Pharyngobasilar fascia
Parapharyngeal space	Fat Vessels Mandibular nerve branches
Masticator Space	Muscles of mastication Mandible Inferior alveolar nerve
Parotid Space	Parotid gland Facial nerve Vessels (ECA*, RMV**)
Carotid Space	Internal carotid artery Internal jugular vein Cranial nerves IX, X, XI Lymph nodes Sympathetic plexus
Retropharyngeal space	Fat Lymph nodes
Prevertebral Space	Vertebral artery and vein Brachial plexus Phrenic nerve Prevertebral & Scalene muscles Vertebral body

**ECA: External carotid artery, **RMV: Retromandibular vein*

of origin as well as the imaging characteristics provide important clues to the identity of a tumor. Other important features to analyze include the extent of the lesion, involvement of adjacent vascular, neural, soft tissue and osseous structures, compromise of the airway if present, and adenopathy. These features impact treatment planning and prognosis. Perineural spread and extension to the skull base should also be excluded. Special attention to cranial nerves V, VII and IX - XII is warranted, as they traverse the skull base and suprahyoid neck. Enhanced images maximize sensitivity for evaluating cranial nerve involvement.

As described above, the manner in which the **parapharyngeal space** is displaced provides a key indicator as to the site of origin of an adjacent mass. It is uncommon for a tumor to arise within the parapharyngeal space, but occasionally, a minor salivary gland tumor, neuroma or a paraganglioma will arise within this space. A lesion primary to the parapharyngeal space will generally be surrounded by fat. The presence of parapharyngeal fat between a lesion in this location and the deep lobe of the parotid gland helps localize it as extraparotid in origin. It is much more common for the parapharyngeal space to be displaced by a lesion originating within one of the adjacent compartments.

A lesion arising within the **pharyngeal mucosal space** displaces the parapharyngeal space posterolaterally. The most common pharyngeal mucosal space neoplasm is squamous cell carcinoma. (which frequently arises within the Fossa of Rosenmuller, or lateral recess.) MR provides superior soft tissue contrast relative to CT, allowing for more accurate assessment of the mucosal space. Superficial lesions may be difficult to detect with either modality, thus pharyngoscopy is a vital component of the tumor survey. This is especially true for patients who have been treated, as pharyngoscopy has proven more sensitive for the detection of local recurrence than CT or MR. The primary advantage of cross sectional imaging is evaluating for deep extension, which cannot be assessed via direct visualization of the mucosa.

Other lesions which may arise in this space include lymphoma and minor salivary gland tumors. A benign, midline nasopharyngeal cyst which is encountered in up to 4% of scanned patients is the Tornwaldt's cyst. It is clinically important only if it becomes infected. Table 2 summarizes common lesions encountered in the suprahyoid spaces.

A lesion arising within the **masticator space** will tend to displace the parapharyngeal space posteromedially as it expands. The most common lesions intrinsic to the masticator space are odontogenic infections, which are encountered more frequently than neoplasms in this compartment. Sarcomas, lymphoma and squamous cell carcinoma represent the most common tumors arising within this space.

A lesion arising within the **parotid space** will impact the parapharyngeal space if it involves the deep lobe. Such lesions will displace the parapharyngeal space anteromedially as they expand. There should be no fat interposed between the lesion and the parotid gland when the mass arises within the gland, and it should displace the carotid artery posteriorly. As the mass expands medially, it will extend into the stylomandibular notch, expanding it as the lesion enlarges. The most common lesions to arise within the parotid gland include benign mixed tumor (pleomorphic adenoma), which characteristically has a lobulated, well-defined margin.

Malignancies within the parotid gland are much less common, and are seen with greater frequency in the smaller salivary glands. The most frequently encountered salivary gland malignancy is mucoepidermoid carcinoma. When multiple lesions are present, consider Warthin´s tumor, acinic cell carcinoma, intraparotid nodal metastases, NHL, and benign lymphoepithelial lesions associated with AIDS. MR imaging characteristics contribute to differentiating these lesions, although distinguishing a benign from a malignant primary parotid neoplasm is not always reliable. In general, carcinomas tend to invade the adjacent muscles of mastication, and show enhancement following administration of a gadolinium chelate. Pleomorphic adenomas often have a lobulated contour, enhance following contrast administration, and do not infiltrate adjacent muscles. Warthin´s tumors usually do not enhance, and display heterogeneous signal on long-TR images.

Lesions primary to the **carotid space** (sometimes referred to as the retrostyloid parapharyngeal space) will tend to displace the parapharyngeal fat anterolaterally. Expansion of the lesion will also result in *anterior* and lateral displacement of the styloid process. The most common lesions encountered within the carotid space are schwannomas and glomus tumors. The latter will often be characterized by punctate flow voids, a finding which is less consistent in smaller lesions (under 2 cm). These tumors usually displace the internal carotid artery anteriorly. If there is *posterior*

Table 2. Lesions of the suprahyoid head & neck

COMPARTMENT	LESIONS
Pharyngeal mucosal space	Squamous cell carcinoma (SCCA) Lymphoma (NHL) Minor salivary glands Tornwaldt´s cyst
Parapharyngeal space	Rare: minor salivary gland tumor *Usually secondarily involved*
Masticator Space	Sarcoma Lymphoma Squamous cell carcinoma Rhabdomyosarcoma
Parotid Space	Pleomorphic adenoma Warthin´s tumor Mucoepidermoid carcinoma Adenoid cystic carcinoma Metastases: SCCA, melanoma
Carotid Space	Glomus tumor Schwannoma Nodal metastases (SCCA) (Vascular lesions)
Retropharyngeal space	Nodal metastases (SCCA, NHL, others) Direct invasion (SCCA) (Infection, vascular lesions, tortuous ICA)
Prevertebral Space	Vertebral body tumor Neural tumors (schwannoma, neurofibroma) Inflammatory or degenerative spine dz) (Vascular lesions)

displacement of the carotid artery, consider a deep lobe parotid lesion or a lesion in the parapharyngeal space.

A mass arising within the **retropharyngeal space** displaces the parapharyngeal space anterolaterally. The pharyngeal mucosal space will be displaced ventrally, and the prevertebral muscles are compressed against the vertebral column. While the infrahyoid portion of the retropharyngeal space contains no lymph nodes, the suprahyoid segment does. Thus, a nodal pattern of disease is generally found in this compartment. Infection is the most common category of pathology effecting the retropharyngeal space, often secondary to extracapsular extension from involved nodes. Nodal involvement by squamous cell carcinoma or lymphoma represent the most frequently encountered neoplasm. Proximity to the airway and the difficulty in clinically evaluating nodal disease in this space make it an important imaging consideration. In addition, this compartment is a potential conduit for the spread of disease between the neck and the mediastinum.

Prevertebral space lesions will also displace the pharyngeal mucosal space anterolaterally, accompanied by ventral displacement of the prevertebral musculature. The latter distinguishes prevertebral origin lesions from those which arise within the retropharyngeal space. The most common prevertebral space lesion is abscess secondary to adjacent osteomyelitis. Medistatic lesions involving the vertebral column may also extent into the prevertebral space. Primary bone tumors are much less common.

CONCLUSION

Evaluation of head and neck lesion requires consideration of the space of origin, which is localized by determining the center of the lesion. Assessing the effect of the mass on the parapharyngeal space helps localize the site of origin. When dealing with posterior masses, the interaction with the parapharyngeal space as well as the prevertebral musculature can help distinguish retropharyngeal from prevertebral masses. Evaluation of the skull base is critical, to exclude extension to involve the osseous structures, and to rule out perineural extension. Careful evaluation of the cranial vault to exclude intracranial extension is also important, especially when skull base involvement or perineural spread is present. Because MR allows multiplanar imaging with superior contrast resolution, it is the imaging modality of choice for evaluating these tumors. Computed tomography serves as an adjunctive modality to assess for and characterize bone involvement, and to evaluate tumoral calcifications.

Selected Bibliography

[1] Barakos, JA, Advances in Magnetic Resonance Imaging of the Head and Neck. Topics in Magnetic Resonance Imaging 1994; 6(3): 155-165

[2] Barakos JA, Dillon WP, Chew WM. Orbit, Skull Base, and Pharynx: Contrast?enhanced Fat Suppression MR Imaging. Radiology 1991; 179:191-198.

[3] Chong VFG, Yoke FF. Detection of Recurrent Nasopharyngeal Carcinoma: MR Imaging versus CT. Radiology 1997; 202:463-470.

[4] Davis WL, Harnsberger HR, Smoker WRK, et al. Retrophayngeal Space: Evaluation of Normal Anatomy and Diseases with CT and MR Imaging. Radiology 1990; 174:59-64.

[5] Dublin MD, Teresi LM, Bradley WG Jr, Jordan JE, et al. Conspicuity of Tumors of the Head and Neck on Fat-Suppressed MR Images: T2-Weighted Fast-Spin-Echo Versus Contrast-Enhanced T1-Weighted Conventional Spin-Echo Sequences. AJR 1995; 164:1213-1221.

[6] Harnsberger HR, Osborn AG. Differential Diagnosis of Head and Neck Lesions Based on Their Space of Origin. 1. The Suprahyoid Part of the Neck. AJR 1991; 157:147-154.

[7] Hudgins PA, Gussack GS. MR Imaging in the Management of Extracranial Malignant Tumors of the Head and Neck. AJR 1992; 159:161-169.

[8] Joe VQ, Westesson P, Tumors of the Parotid Gland: MR Imaging Characteristics of Various Histologic Types. AJR 1994; 163:433-438

[9] Laine FJ, Braun IF, Jensen ME, et al. Perineural Tumor Extension through the Foramen Ovale: Evaluation with Mr Imaging. Radiology 1990; 174:65-71.

[10] Mukherji SK, Schiro S, Castillo M, et al. Proton MR Spectroscopy of Squamous Cell Carcinoma of the Upper Aerodigestive Tract: In Vitro Characteristics. AJNR Sept 1996; 17:1485-1490.

[11] Muraki AS, Mancuso AA, Harnsberger HR. CT of the Oropharynx, Tongue Base, and Floor of the Mouth: Normal Anatomy and Range of Variations, and Applications in Staging Carcinoma. Radiology 148: 725-731, September 1983.

[12] Oot RF, Melville GE, New PFJ, et al. The Role of MR and CT in Evaluating Clival Chordomas and Chondrosarcomas. AJR 1988; 151:567-575.

[13] Paling MR, Black WC, Levine PA, et al. Tumor Invasion of the Anterior Skull Base: A Comparison of MR and CT Studies. JCAT 1987; 11(5): 824-830.

[14] Parker GD, Harnsberger HR. Clinical? Radiological Issues in Perineural Tumor Spread of Malignant Diseases of the Extracranial Head and Neck. RadioGraphics 1991: 11:383-399.

[15] Robinson JD, Crawford SC, Teresi LM, et al. Extracranial Lesions of the Head and Neck: Preliminary Experience with Gd-DTPA-enhanced MR Imaging. Radiology 1989; 172:165-170.

[16] Som PM, Braun IF, Shapiro MD, et al. Tumors of the Parapharyngeal Space and Upper Neck: MR Imaging Characteristics. Radiology 1987; 164: 823-829

[17] Som PM, Sacher M, Stollman AL, et al. Common Tumors of the Parapharyngeal Space: Refined Imaging Diagnosis. Radiology 1988; 169:81-85

[18] Smoker WRK, Harnsberger HR. Differential Diagnosis of Head and Neck Lesions Based on Their Space of Origin. 2. The Infrahyoid Portion of the Neck. AJR 1991: 157:155-159.

[19] Teresi LM, Lufkin RB, Vinuela F, et al. MR Imaging of the Nasopharynx and Floor of the Middle Cranial Fossa Part I. Malignant Tumors. Radiology 1987; 164:811-816

[20] Teresi LM, Lufkin RB, Vinuela F, et al. MR Imaging of the Nasopharynx and Floor of the Middle Cranial Fossa Part II. Malignant Tumors. Radiology 1987; 164:817-821.

[21] Tien RD, Hesselink JR, Chu PK, et al. Improved Detection and Delineation of Head and Neck Lesions with Fat Suppression Spin?Echo MR Imaging. AJNR 1991; 12:19-24.

[22] van den Brekel MWM, Castelijns JA, Stel HV, et al. Detection and Characterization of Metastatic Cervical Adenopathy by MR Imaging: Comparison of Different MR techniques. Journal of Computer Assisted Tomography July/Aug 1990 14(4): 581-589

[23] van den Brekel MWM, Stel HV, Castelijns JA, et al. Cervical Lymph Node Metastasis: Assessment of Radiologic Criteria. Radiology 1990; 177:379-384.

[24] Volle E, Treisch J, Claussen C, et al. Lesions of Skull Base Observed on High Resolution Computed Tomography: A Comparison with Magnetic Resonance Imaging. Acta Radiol 1989; 30:129-134.

[25] Yasumoto M, Shibuya H, Takeda M, et al. Squamous Cell Carcinoma of the Oral Cavity: MR Findings and Value of T1- Versus T2-Weighted Fast Spin-Echo Images, AJR 1995; 164:981-987

[26] Yousem DM, Hatabu H, Hurst RW, et al. Carotid Artery Invasion by Head and Neck Masses: Prediction with MR Imaging. AJR 1995; 195:715-720

[27] Zoarski GH, Parker JR, Lufkin RB, et al. Efficacy of Gadoteridol for Magnetic Resonance Imaging of Extracranial Head and Neck Pathology. Invest Radiol 1992; 27:S53-S57.