Emergency imaging assessment of acute, non-traumatic conditions of the head and neck

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Learning objectives

Description and illustration of clinical and imaging findings seen with the spectrum of head and neck infections.
Background

Patients often present to the emergency department with a wide variety of non-traumatic infectious, inflammatory, and neoplastic conditions of the head and neck. Because the use of cervical and neck computed tomography (CT) has become routine in the emergency setting, knowledge of the imaging findings of common acute conditions of the head and neck is essential to ensure an accurate diagnosis of these potentially life-threatening conditions, which include oral cavity infections, tonsillitis and peritonsillar abscess, sialadenitis, parotiditis, diskitis, thrombophlebitis, periorbital and orbital cellulitis, infectious cervical lymphadenopathy, and various neoplasms. Less common conditions that require rapid diagnosis and treatment include epiglottitis, invasive fungal sinusitis, angioedema, and deep neck abscess. Familiarity with these conditions enables the radiologist to make a prompt diagnosis, assess the extent of disease, and evaluate for potential complications. CT is the first-line imaging modality in the emergency setting; however, magnetic resonance imaging plays an important secondary role.

Definition:

DNSIs are infections in the potential spaces and facial planes of the neck which could be lymphadenitis, cellulitis, necrotic node or abscess in nature. Although the increased use of antibiotics has reduced the incidence of DNSIs, they still remain an important clinical entity with serious potential complications, such as airway obstruction, jugular vein thrombosis, carotid artery aneurysm or rupture, mediastinitis and sepsis. Infection of the ears, nose, or throat may spread to deep neck spaces by direct continuity or by lymphatic drainage to lymph nodes in these spaces. The facial layers of the neck and natural defense mechanisms help to prevent spread of these infections. However, if the infection is not adequately treated, a severe lymphadenitis in the lymph nodes draining the primary infection site or cellulitis in the soft tissues may progress to a purulent fluid collection called abscess. Abscesses of the neck may involve many spaces simultaneously through the potential pathways of extension. The value of imaging lies in delineating the anatomical extent of the disease process, identifying the source of infection and detecting complications.

Anatomy of the deep neck spaces:

The potential spaces of the neck can be divided into groups in relation to the hyoid bone. There are six suprahyoid spaces, one infrahyoid space and five spaces that span the length of the neck.

Spaces spanning the entire neck

The superficial space can be divided into two parts by the platysma muscle. This space is similar to subcutaneous tissue and contains lymphatic channels. The deep portion contains the external jugular vein and lymph nodes. Abscesses that present in this
space can be drained by incising along Langer's lines. Superficial space infections can potentially extend to the axilla and chest along the subcutaneous fat planes but they rarely extend deeper past the superficial layer of the deep fascia.

The retropharyngeal space extends from the skull base to the upper mediastinum at the level of T1-T2. Its anterior border is the buccopharyngeal fascia and its posterior border is the alar fascia. It communicates with the anterior visceral space inferiorly. The space is divided in the midline by a raphe that attaches the superior constrictor muscle to the alar fascia. It contains retropharyngeal lymph nodes (Glands of Henle) that typically atrophy after the age of five.

The danger space extends from the skull base to the diaphragm. The anterior border is the alar fascia and the posterior border is the prevertebral layer of the prevertebral fascia. It contains loose areolar tissue.

The prevertebral space extends from the skull base to the coccyx. The anterior border is the prevertebral layer of the prevertebral fascia and posteriorly it is limited by the anterior longitudinal ligament of the vertebral bodies. Laterally the space is confined by the transverse processes of the vertebral bodies.

The visceral vascular space is the potential space within the carotid sheath. It extends from the skull base to the mediastinum. It contains the carotid artery, internal jugular vein and vagus nerve. It also receives lymphatic drainage from all the lymphatic vessels in the head and neck.

Suprahyoid spaces

The submandibular space is bounded by the mandible anteriorly and laterally, the lingual mucosa superiorly, the hyoid postero-inferiorly and the superficial layer of the deep cervical fascia inferiorly. The mylohyoid muscle divides this space into a superior sublingual space and an inferior submylohyoid space. The sublingual space contains loose areolar tissue, the hypoglossal and lingual nerves, the sublingual gland and Wharton's duct. The submylohyoid space contains the anterior bellies of the digastrics and the submandibular glands. These two subdivisions freely communicate around the posterior border of the mylohyoid.

The pharyngomaxillary space is also known as the parapharyngeal space or lateral pharyngeal space. It is a difficult space to visualize because of its odd shape and multiple boundaries. It spans from the skull base to the hyoid bone. The superior portion of the space at the skull base is larger than the space inferiorly at the hyoid. This gives the described inverted cone shape. The lateral border is the superficial layer of deep cervical fascia that overlies the medial portion of the medial pterygoid and deep lobe of the parotid gland. Medially the space is limited by the buccopharyngeal fascia covering the superior pharyngeal constrictor. The prevertebral fascia overlying the deep neck musculature is the posterior limit. The pterygomandibular raphe (which separates the superior constrictor from the buccinator) is the anterior limit of the space. The styloid
process divides the space into two compartments. The poststyloid portion is also referred to as the neurovascular compartment because the carotid sheath runs through it. Cranial nerves IX, X, XI, XII and the sympathetic chain also run through this space. The prestyloid portion is also referred to as the muscular compartment because of its proximity to the pterygoids and constrictor. Fat, connective tissue and lymph nodes are also contained in the prestyloid compartment. The stylopharyngeal aponeurosis of Zuckerkandel and Testus is formed by the intersection of the alar, buccopharyngeal and stylomuscular fascia and acts as a barrier to the spread of infection from the prestyloid compartment to the poststyloid compartment.

The parotid space is created by the superficial layer of deep cervical fascia as it splits to surround the mandible and parotid gland. The fascia sends dense connective tissue septa from the capsule into the gland. In addition to the parotid gland, this space contains the parotid lymph nodes, the facial nerve and posterior facial vein. The fascial envelope is deficient on the supero-medial surface of the gland, facilitating direct communication between this space and the parapharyngeal space.

The peritonsillar space is bound by the capsule of the palatine tonsil medially, the superior pharyngeal constrictor medially. The superior border is the anterior tonsillar pillar and the posterior tonsillar pillar is the inferior border. The space contains loose areolar tissue and minor salivary glands.

The masticator space is formed by the superficial layer of the deep cervical fascia as it surrounds the masseter laterally and the pterygoid muscles medially. This space contains these muscles as well as the body and ramus of the mandible, the inferior alveolar nerves and vessels and the tendon of the temporalis muscle. The masticator space is in direct communication with the temporal space superiorly deep to the zygoma. This space is antero-lateral to the pharyngomaxillary space.

The temporal space has as its lateral boundary the superficial layer of deep fascia as it attaches to the zygoma and temporal ridge and its medial boundary the periosteum of the temporal bone. It is subdivided into superficial and deep spaces by the body of the temporalis muscle. This space contains the internal maxillary artery and the mandibular nerve.

Infrahyoid spaces

The anterior visceral space is a potential space within the middle layer of deep cervical fascia. It also referred to as the pretracheal space. It is continuous with the retropharyngeal space laterally. It is bounded by the thyroid cartilage superiorly and the anterior superior mediastinum down to the aortic arch inferiorly. Posteriorly it is limited by the anterior esophageal wall. It contains the thyroid and parathyroid glands and surrounds the trachea.

Deep neck infections (DNI) presentation:
When considering both adult and pediatric patients, the average age of patients presenting with DNI is between 40 to 50 years. In pediatric patients, these infections can occur at any age. The most common age group is between three to five years of age with a slight male predominance. Retropharyngeal abscesses are more common in the pediatric population because of the presence of lymph nodes that atrophy with age.

Patients with deep neck infections can present in a variety of ways. The two most common symptoms were sore throat and odynophagia. When disregarding all patients with peritonsillar abscesses, the most common symptoms were neck swelling and neck pain. In pediatric patients, the most common presenting symptoms are fever, decreased oral intake, odynophagia and malaise. Depending on the location of the DNI, trismus may be present but overall it was only present in up to 20% of patients in multiple reviews. Patients may present in respiratory distress and may have impending upper airway obstruction or concomitant pneumonia. Dehydration from lack of oral intake and intolerance of their own secretions are also common symptoms. Other clinical signs include torticollis from SCM inflammation, neck pain with neck movement, otalgia, headache, and vocal quality changes. Parents and spouses may note worsening snoring and sleep apnea.

**Etiology:**

When considering all deep neck infections, the most common etiology is probably pharyngitis or tonsillitis. When excluding peritonsillar abscesses, the most common etiology is odontogenic infection. These infections occur in patients who have had recent dental extractions and in patients in lower socioeconomic groups who have no access to dental health care. In pediatric patients, these infections are usually a result of suppurative lymph node following upper respiratory infections, pharyngitis, otitis media, and tonsillitis.

**Microbiology:**

The most common gram positive aerobes were Streptococcal species followed by Staphylococcal species. Beta hemolytic streptococci were the predominant subgroup followed by *Streptococcus viridans* and *Staphylococcus aureus*. The predominant gram negative aerobes were *Klebsiella* species and *Neisseria* species. *Peptostreptococcus* and *Bacteroides* species were the most common anaerobic isolates.
Fig. 1: Cross-sectional anatomy of some important deep neck spaces. (a) Masticator space (brown), parotid space (yellow), pre-styloid parapharyngeal space (orange), carotid space (purple); (b) submandibular space (light green) and sublingual space (light blue) are depicted on the right side of the neck.

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Fig. 2: Cross-sectional anatomy of some important deep neck spaces. Danger space (red), retropharyngeal space (blue) and prevertebral space (green) are depicted on the right side of the neck in the axial planes at the level of the neck; and mediastinum.
Findings and procedure details

Contrast-enhanced computed tomography (CT) imaging is the modality of choice in DNI. As the RPS, anterior visceral, danger and prevertebral spaces extend into the mediastinum, it is imperative to include sections of the mediastinum up to the level of the aortic arch in the CT imaging coverage. The use of high-spatial-frequency (bone) reconstruction algorithm is often rewarding in identifying the source of infections (osteomyelitis, caries, spondylodiscitis, radiodense foreign bodies and silolithiasis). A quick review of the images in lung window settings helps to identify locules of gas in soft tissues. Fluid and fat stranding in the subcutaneous tissues and along the fascial planes may be representative of cellulitis. Increased density and enhancement of muscles may be seen in myositis. Abscesses in the deep neck spaces, like elsewhere in the body, require drainage and are demonstrated on CT imaging as rim enhancing lesions with central hypodense, non-enhancing areas of necrosis. Typically, abscesses contain pockets of gas within. Phlegmon, on the other hand, are not amenable to drainage and appear as solid, poorly or non-enhancing soft tissue masses. A delayed, post-contrast CT image taken after several minutes depicts subtle central enhancement in a poorly liquefied lesion, thus avoiding unnecessary surgery. Unfortunately, the distinctions between the two aforementioned processes are not always clear on CT imaging, and up to a quarter of ring-enhancing lesions are not drainable at surgery. Magnetic resonance (MR) imaging provides the best contrast resolution and may be used as a problem-solving tool in these cases. In the bone marrow and soft tissues can be easily detected by specific sequences, particularly inversion recovery sequences. Gadolinium-based intravenous contrast administration (along with fat suppressed T1-weighted sequences) is necessary for accurate assessment of DNI. Ultrasonography is useful as an initial or alternative modality for identification of abscesses. It evaluates whether the abscess is liquefied enough to be drained and may also assist in the drainage itself. However, deep-seated infections are not accessible by ultrasonography, and cross-sectional imaging is necessary for better localization of the infections. Plain films may be diagnostic in acute supraglottitis and may help to identify retropharyngeal and prevertebral infections. However, the exact localization of the infectious focus is often difficult with this modality. Dental radiographs are useful in identifying odontogenic sources of infection. The role of MR imaging in DNI is limited by the long acquisition times and the unstable general condition of these patients, who may be critically ill. This modality is particularly useful for evaluation of suspected osteomyelitis, since edema.

Complications:

The incidence of complications from deep neck space infections has remarkably decreased since the advent of antibiotic therapy. Despite this, the potentially devastating outcomes associated with these complications remind the physician to remain vigilant for their signs. Airway obstruction and asphyxiation is a potential complication of any deep neck
infection, but has been most commonly associated with Ludwig's angina. Early evaluation and management of these patients is paramount
Images for this section:

Fig. 3: Ethmoiditis complicated by right orbital subperiosteal abscess.

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Fig. 4: Head and neck infection

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**Fig. 5:** Mastoiditis

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**Fig. 6:** Axial contrast-enhanced CT images reveal an abscess in the sublingual space

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Fig. 7: Adenophlegmon

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Fig. 8: Epiglotitis

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Conclusion

Imaging delineates the exact anatomical extent of DNI, identifies their possible sources and detects complications. Imaging findings may alter surgical management. Extensive surgery may be avoided if non-abscess inflammatory changes are differentiated confidently from abscesses. Imaging-assisted abscess drainage procedures may be a less invasive option to surgery.
References


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