Deep Neck Spaces radiology and review of deep neck infections at King Abdulaziz University Hospital

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Abstract
The anatomy of the deep neck spaces is a complex one, and deep neck infections are a common clinical problem in all age groups. Otolaryngologists should be familiar with the detailed anatomy and divisions of the neck in order to properly diagnose and treat patients. Thus, knowledge of the radiological anatomy is paramount for accurately localizing and evaluating the extent of the deep neck inflammatory processes. In this study, we present the anatomy of normal deep neck spaces in computerized tomography and magnetic resonance images. The computerized tomography images of 56 patients that presented with symptoms indicative of deep neck infections were also reviewed to illustrate the different patterns of neck infections and their relationship with thoracic abnormalities. Because of the frequent thoracic abnormalities associated with neck infections, we recommend performing a CT scan of chest in the same sitting with the CT of neck and absence of ring enhancement does not exclude the presence of abscess.

Key words: infection, tomography and magnetic resonance

Introduction

Infection of the neck is a common clinical problem in all age groups, especially among children and young adults1–3. Imaging studies that use computerized tomography (CT) and magnetic resonance imaging (MRI) are frequently required to confirm a diagnosis and, more importantly, to localize the infectious process and to delineate an abscessed cavity. Hence, knowledge of the anatomy is paramount for localizing and evaluating the extent of the inflammatory process4–7.

Neck infections can be categorized as either deep (i.e., intrinsic) or extrinsic8–10. Intrinsic infections include Ludwig’s angina, peritonsillar, parapharyngeal, and retropharyngeal inflammation, while extrinsic infections comprise cervical adenitis and submandibular, submental, and masticator space infections. The causative organisms of neck infections such as lymphadenitis are varied but can be subdivided into bacterial, fungal, parasitic, or viral. Unfortunately, if the treatment of a neck infection is delayed or inadequate, mediastinal extension may ensue and result in pain, dyspnea, asphyxia secondary to aspiration, swelling with mediastinal widening, and dysphagia from esophageal compression11.

The source of neck infections is unknown in up to 50% of cases. Known source are mainly extrinsic such as infections. Some neck infections result from supplicative adenitis, with the primary infection often originating from the mucosa of the oral cavity, paranasal sinuses, and pharynx. Dental caries and periodontal disease of the teeth are other sources frequently implicated in deep neck infection12,13.

Neck Anatomy
A. Fascial Layers in the Neck
The fascial layers in the neck are either superficial or deep. The superficial fascia lies just below the subcutaneous tissue and envelopes the platysma muscle. The deep fascial layers comprise the investing, visceral, and prevertebral fasciae14. The investing fascia envelopes the sternocleidomastoid and trapezius muscles and divides to form the capsules of the submandibular and parotid glands (Figure 1). Both the superficial fascia and the investing layer surround the entire neck14. The visceral (pretracheal) fascia forms a circle in the center of the anterior neck (Figure 2). Within its bounds are the pharynx, trachea, esophagus, and thyroid and parathyroid glands. Posteriorly, the visceral fascia lies between the esophagus and the vertebral bodies. Anteriorly, the visceral fascia divides to form the capsule of the thyroid gland14. The prevertebral fascia encircles the spine and the paraspinal muscles (Figure 3). Anterior to the vertebral bodies, the prevertebral fascia divides into 2 layers: (a) the alar fascia (anterior) and (b) the true prevertebral fascia (posterior). Between the alar and true prevertebral fasciae is the important danger space that is involved in the spread of infection14.
The carotid sheath is formed with contributions from all 3 layers of the deep cervical fascia. The sheath surrounds the common carotid artery, internal jugular vein, and vagus nerve. When the common carotid artery divides into the internal and external branches, the external carotid artery leaves the carotid sheath, and the internal carotid artery continues within the sheath to the base of the skull. The infrahyoid fascia, formed with contributions from the investing and visceral layers of the deep cervical fascia, surrounds the strap muscles.

The submandibular space corresponds to the submental and submandibular triangles. The roof of the submandibular space is the mylohyoid muscle. The submandibular space is said to be in the visceral space, which includes the larynx, trachea, esophagus, thyroid gland, and parathyroid glands. The visceral fascia is considered to be in the visceral space, and the prevertebral fascia is considered to be in the prevertebral space. Structures within the visceral fascia include the spine, paraspinal muscles, vertebral artery, and phrenic nerve, and are in the prevertebral space. The retropharyngeal lymph nodes are located within the true retropharyngeal space. The retropharyngeal space lies between the visceral fascia and the alar fascia. The retropharyngeal space is so termed because infections can spread vertically along the entire length of the neck and torso.

B. Neck Spaces

The cervical fascia divides the neck into several distinct compartments (spaces). One should be aware of these spaces and their defining landmarks, not only because they affect the spread of infection, but also because they influence the differential diagnosis of pathologic findings.

The parapharyngeal space lies between the layers of the deep cervical fascia, with the pharynx medial, the carotid sheath posterior, and the parotid gland lateral. The styloid process of the temporal bone, along with its associated muscles and ligaments, divides the parapharyngeal space into the prestyloid and neurovascular compartments.
The prestyloid parapharyngeal space contains fat and extends only to the level of the hyoid bone. The neurovascular space corresponds to the carotid sheath and extends the length of the neck (Figure 8).

Below the level of the hyoid bone, there are fat-filled spaces anterior and posterior to the carotid sheath. These are the anterior and posterior cervical spaces. The posterior cervical space corresponds to the posterior triangle and contains the spinal accessory and dorsal scapular nerves, along with the spinal accessory lymph node chain (Figure 9).

<table>
<thead>
<tr>
<th>The anatomical space</th>
<th>Number of patients</th>
</tr>
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<tbody>
<tr>
<td>Peritonsillar</td>
<td>24</td>
</tr>
<tr>
<td>Submandibular</td>
<td>14</td>
</tr>
<tr>
<td>Parapharyngeal</td>
<td>14</td>
</tr>
<tr>
<td>Retropharyngeal</td>
<td>8</td>
</tr>
<tr>
<td>Sublingual</td>
<td>4</td>
</tr>
<tr>
<td>Anterior cervical</td>
<td>8</td>
</tr>
<tr>
<td>Posterior cervical</td>
<td>2</td>
</tr>
<tr>
<td>Parotid space</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 1: The neck spaces involved in infection as determined by CT.
The spaces of neck involved, as determined by CT, were as follows (Table 1): -
- Lymph nodal abnormalities were identified in 36 patients (32 %). These abnormalities were in the form of:
  1. Enlargement (using a 1.5 short axis diameter as the limit in all levels)
  2. Abnormal enhancement (significant or ring enhancement)
  3. Central hypodensity
- Ring enhanced fluid collections were found in 30 patients (53.6 %).
- Air pockets were detected in 20 patients (35.7 %).
- 4 patients with air pockets (7.1 %) and without ring enhancement were shown to have pus during needle aspiration.
- 12 patients (21.4 %) had mediastinal extensions in the form of mediastinal ring enhancing lesions or air pockets.
- 4 patients (7.1 %) had lung parenchymal changes in the form of lung abscess and infiltrations.
- 2 patients (3.7 %) had mediastinal (right hilar) lymph nodal enlargement.
- 4 patients (7.6 %) had multiple chest wall abscesses.
- 8 patients (14.3 %) had a pleural effusion.
- The most common organisms isolated in the pyogenic infections were Staphylococcus aureus (14 patients, 25 %) and Klebsiella pneumoniae (8 patients, 14.3 %).
- Mycobacterium TB was the source of the infection in 24 patients (42.9 %).
- None of our patients (0 %) had jugular vein thrombosis.
- 2 patients had a large, infected branchial cleft cyst that extended inferiorly to the mediastinum (Figure 10).
- 4 patients (7.1 %) had Ludwig’s angina (Figure 11).
- 6 patients (10.7 %) had necrotizing fasciitis (Figure 12).

Discussion

The chief modality for the evaluation of a neck infection is contrast helical CT carried out in the axial plane. 32 out of the 56 patients (57%) in our study were diabetic (n = 20), had HIV (n = 4), suffered from dental problems (n = 6), or had a preexisting pathology (n = 2) that consisted of a large branchial cyst extending into the mediastinum. We believe that these factors played a predisposing role in the neck infections for this group of patients. In support of dental problems playing a role in causing infection, Chowdhury et al and Kim et al have found that dental caries and periodontal disease of the teeth are frequently implicated in deep neck infections12, 13.

In our study, the most frequently infected neck space was the peritonsillar space (n = 24) (42.9%), followed by the parapharyngeal (n = 14) (25%) and the submandibular (n = 14) (25%) spaces. Consistent with these findings, in a large study that included 184 patients with deep neck infections, Wang et al, found that the neck spaces most frequently involved in infection were the parapharyngeal (n = 77) (41.9%), peritonsillar (n = 59) (32.1%) and submandibular (n = 55) (29.9%) spaces18. In another retrospective study that included 117 children, Ungkanont et al.found the most frequent neck space involved was the peritonsillar space (49%), followed by the retropharyngeal space (22%), the submandibular space (14%), the buccal space (11%), and the parapharyngeal space, indicating that children may differ from adults in their susceptibility to different types of infections1. In our study, the only child (below 16 years of age) was a 2 year old, HIV-positive male with a diffuse infective process and early abscess formation in the submandibular region. Based on its presence, Mycobacterium tuberculosis was presumed to be the causative agent.

Retropharyngeal space infections were historically believed to occur almost exclusively in children less than 6 years of age19. However, with the increase in the immunocompromised patient population, these infections have become more frequent in adults, occurring more commonly in males than in females (2:1) . In our study, all the patients that had retropharyngeal space infection were adults (n = 8). In conformity with the general population ratio, 6 male patients and 2 female patient had this type of infection. The neck space infections were either peritonsillar (n = 6) or parapharyngeal (n = 2). Patients with retropharyngeal space infections often present with fever, chills, odynophagia, sore throat, dysphagia,
nausea, vomiting, respiratory distress, neck pain, and stiffness. Interestingly, however, in perhaps the first known case in our department, one of these patients presented because of odynophagia, dysphagia, nausea and vomiting. In the first study, we had him swallow barium and then performed a CT of his neck and chest hence, in the absence of signs of infections, barium swallow can help to delineate the infectious process in the retropharyngeal neck space.

The danger point for the spreading of infection is the space situated dorsal to the retropharyngeal space between the alar and prevertebral fascia. This space extends from the skull base to the level of the posterior diaphragm. Infections that involve the retropharyngeal space may enter the danger space and thus extend into the mediastinum.

In our study, 12 patients (21.4%) had mediastinal extensions of the infectious process; 6 from retropharyngeal space infection and 6 from anterior cervical space infection. In addition, suppurative uncontrolled infection of the tonsils may result in a peritonsillar abscess (quinsy) or rarely in a tonsillar abscess. A peritonsillar abscess is an accumulation of pus around the palatine tonsils. If this abscess extends outside the tonsillar fossa, it may involve the lateral retropharyngeal or parapharyngeal spaces. In our study, out of 24 patients with a peritonsillar infection, 6 had retropharyngeal extension and 10 had parapharyngeal extension.

Tuberculosis of the head and neck can involve the cervical lymph nodes, larynx, temporal bone, sinonasal cavity, eye, pharynx, thyroid gland, and skull base. TB is a rare cause of cervical lymphadenopathy in children in the United States and is largely seen in children with AIDS. The only child included in our study was an AIDS patient and had a diffuse neck infection and an enhanced lymph node with central hypodensity. He was shown to have TB. The other patient with AIDS in our study also had a TB neck abscess. Other patients with TB in our study (n = 20) had chest wall abscesses (n = 4), mediastinal lymph nodes (n = 2), lung abscesses (n = 2) and pleural effusion (n = 4).

The most common organism found in pyogenic infections in our study was Staphylococcus aureus (n = 14) (25%), followed by Klebsiella pneumonia (n = 8) (14.3%). In the study of Wang et al, Klebsiella pneumonia was the organism most commonly isolated from infections.

If an abscess is clearly present, a CT scan usually shows a central, low attenuation region surrounded by an enhanced rim. However, the low attenuation center does not necessarily imply the presence of actual pus, as a similar appearance can result from lymph nodes undergoing early liquefaction (pre suppurative phase) and in those that have undergone complete liquefaction necrosis (suppurative phase). Again, the absence of a rim enhancement does not preclude the presence of pus.

Vural et al. studied the accuracy of CT scans of deep infections in the pediatric population. They concluded that CT scans have important limitations in differentiating abscesses and cellulites and that and clinical findings besides a CT-based diagnosis should guide the decision for surgery.
References


