CMEARTICLE

Infections of the deep neck spaces

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ABSTRACT Deep neck infections (DNI) have a propensity to spread rapidly along the interconnected deep neck spaces and compromise the airway, cervical vessels and spinal canal. The value of imaging lies in delineating the anatomical extent of the disease process, identifying the source of infection and detecting complications. Its role in the identification and drainage of abscesses is well known. This paper pictorially illustrates infections of important deep neck spaces. The merits and drawbacks of imaging modalities used for assessment of DNI, the relevant anatomy and the possible sources of infection of each deep neck space are discussed. Certain imaging features that alter the management of DNI have been highlighted.

Keywords: abscess, cellulitis, computed tomography, Ludwig's angina, peritonsillar abscess
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INTRODUCTION

Deep neck infections (DNI) are potentially life-threatening diseases and warrant aggressive management. They are usually polymicrobial and often occur following preceding infections such as tonsillitis/pharyngitis, dental caries or procedures, surgery or trauma to the head and neck, or in intravenous drug abusers.[1,2] Clinical manifestations of DNI depend on the spaces infected, and include pain, fever, swelling, dysphagia, trismus, dysphonia, otalgia and dyspnoea. A rapidly progressive course with fatal outcome may be seen, especially in immunocompromised patients (e.g. diabetes mellitus, HIV infection, steroid therapy, chemotherapy).[1,3] Although the diagnosis of DNI is based on clinical assessment, the extent of the disease process is often difficult to evaluate on inspection or palpation. Compromise of the airway, cervical vessels and spinal canal requires early recognition.[1] Aggressive airway maintainence, intravenous antibiotics and surgical drainage form the cornerstones of management. The value of imaging lies in delineating the exact anatomical extent of DNI and detecting complications. Often, the source of infection can be identified. Thus, the role of imaging in the identification and drainage of abscesses cannot be overemphasised.

ANATOMY OF DEEP NECK SPACES

The three layers of the deep cervical fascia encase the structures of the neck and form the deep neck spaces (Figs. 1 & 2). The parotid, masticator (including the infratemporal fossa), submandibular and the prestyloid parapharyngeal space (PPS) are exclusively suprahyoid in location, and the anterior visceral space is exclusively infrahyoid in location. The prevertebral space, retropharyngeal space (RPS) and poststyloid PPS traverse the neck from the skull base down to the mediastinum. The relevant anatomy of each deep neck space is further discussed separately.

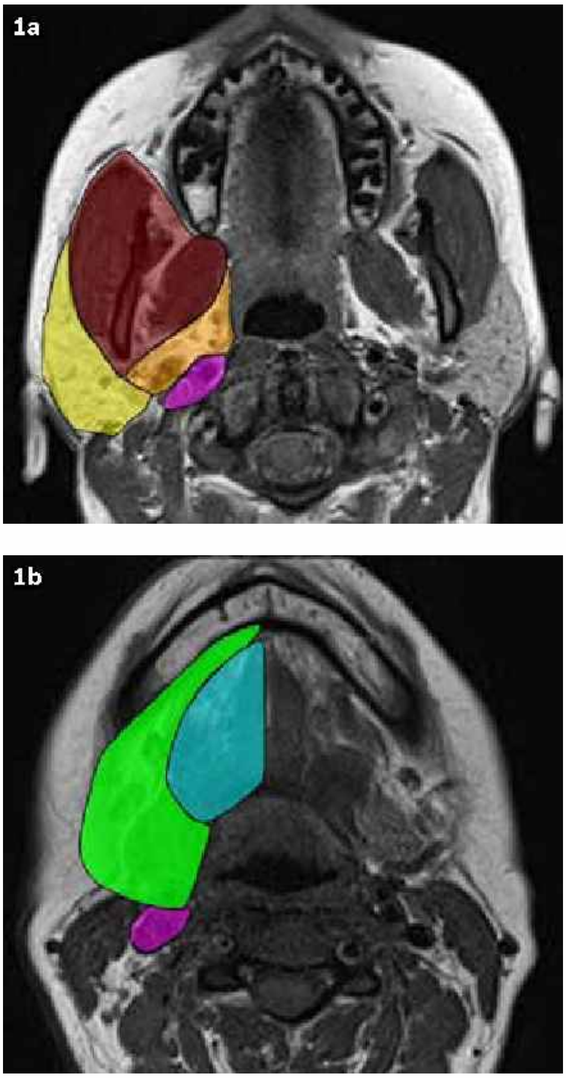

Fig. 1 Cross-sectional anatomy of some important deep neck spaces. (a) Masticator space (brown), parotid space (yellow), prestyloid parapharyngeal space (orange), carotid space (purple); (b) submandibular space (light green) and sublingual space (light blue) are depicted on the right side of the neck.

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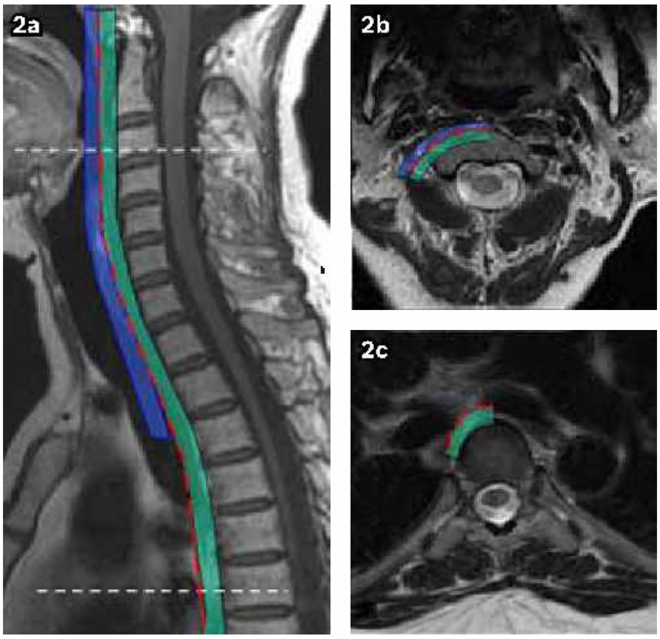

Fig. 2 Cross-sectional anatomy of some important deep neck spaces. Danger space (red), retropharyngeal space (blue) and prevertebral space (green) are depicted on the right side of the neck in the (a) sagittal and (b) axial planes at the level of the neck; and (c) mediastinum.

Fig. 3 Axial contrast-enhanced CT image shows a hypodense solid lesion (arrow) in the left oropharyngeal tonsil extending into the adjacent parapharyngeal space. The imaging features are suggestive of a phlegmon.

Fig. 4 Role of MR imaging as a problem-solving tool. (a) Contrast-enhanced CT image shows a well-defined hypodense lesion in the deep lobe of the right parotid gland (arrow). Differentials of abscess and neoplasm were considered. (b) T2-W MR and (c) post-contrast fat saturated T1-W MR images clearly show rim enhancement in the lesion (arrow). Reactive changes in the parapharyngeal and masticator spaces are also noted (arrowhead), suggesting that an abscess was more likely. The findings were confirmed on surgery.

IMAGING MODALITIES AND FINDINGS

Contrast-enhanced computed tomography (CT) imaging is the modality of choice in DNI.[3] 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. Phlegmons, on the other hand, are not amenable to drainage and appear as solid, poorly or non-enhancing soft tissue masses (Fig. 3).[4] A delayed, post-contrast CT image taken after several minutes depicts subtle central enhancement in a poorly liquefied lesion, thus avoiding unnecessary surgery.[5] Unfortunately, the distinction between the two aforementioned processes is not always clear on CT imaging, and up to a quarter of ring-enhancing lesions are not drainable at surgery.[5] Magnetic resonance (MR) imaging provides the best contrast resolution and may be used as a problem-solving tool in these cases (Fig. 4).

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 oedema

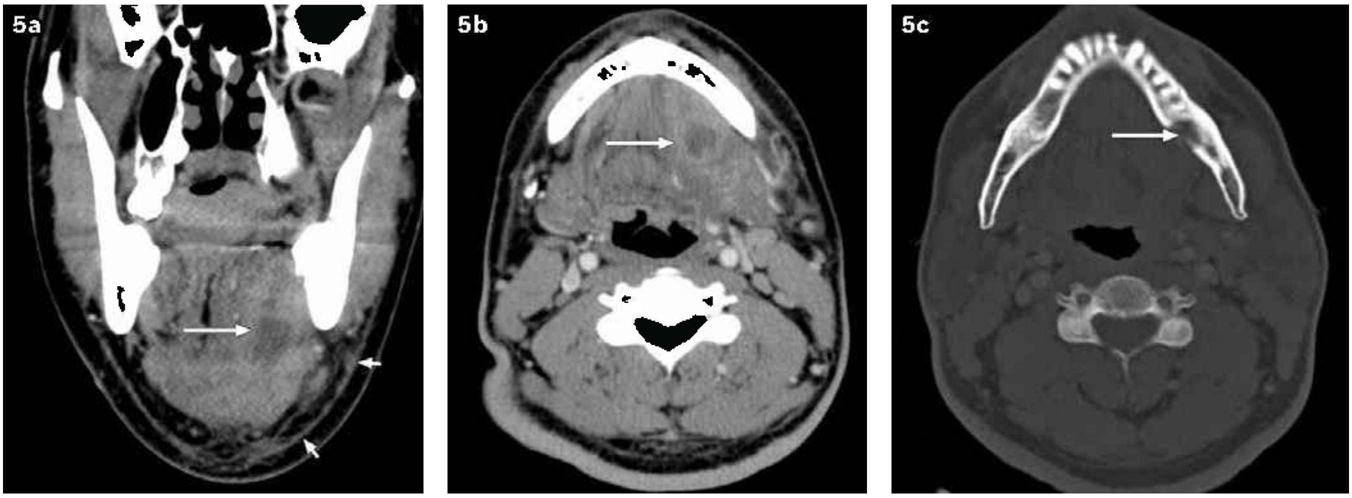

Fig. 5 (a) Coronal and (b) axial contrast-enhanced CT images reveal an abscess (arrow in Fig. 5a) in the left sublingual space. Fascial thickening and fat stranding are noted (arrowheads) in the left submandibular space. (c) Bone window setting identifies the odontogenic source of the infection (arrow).

in the bone marrow and soft tissues can be easily detected by specific sequences, particularly inversion recovery sequences.[6,7] 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.[5,8] However, deep-seated infections are not accessible by ultrasonography, and cross-sectional imaging is necessary for better localisation of the infections. Plain films may be diagnostic in acute supraglottitis and may help to identify retropharyngeal and prevertebral infections. However, the exact localisation of the infectious focus is often difficult with this modality. Dental radiographs are useful in identifying odontogenic sources of infection.[1,4]

INFECTIONS OF INDIVIDUAL DEEP NECK SPACES

Submandibular space

The submandibular space extends from the floor of the oral cavity to the attachment of the superficial layer of the deep fascia, to the mandible to the hyoid bone (Fig. 1b). It is divided by the mylohyoid muscle into supramylohyoid (sublingual) and inframylohyoid (submaxillary or the anatomically correct submandibular) components. Infections of this space commonly originate from an odontogenic source (Fig. 5); other sources of infection include submandibular siloadenitis, lymphadenitis and trauma. DNI may initially be limited to the sublingual or submaxillary spaces. However, the infections can communicate across the posterior border of the mylohyoid and across the midline if not adequately treated.[1,9] Ludwig's angina is an infective cellulitis of bilateral supra- and inframylohyoid spaces, which may present as oedema, fasciitis or large fluid collections involving these spaces.[9] A potential risk of direct spread to the PPS and RPS, and subsequent rapidly progressive airway obstruction, exists with this form of DNI.

Milder infections may respond to intravenous antibiotics, but demonstration of an abscess on imaging warrants surgical drainage. An intra-oral approach is optimal for abscesses that are limited to the sublingual space. However, an extra-oral surgical approach is required for infections involving the inframylohyoid submandibular space. In odontogenic infections, the offending tooth is also removed.[10,11]

Masticator space

The masticator space extends cranio-caudally between the skull base and the mandibular ramus, and transversely between the medial pterygoid and the masseter muscles (Fig. 1a). Infratemporal fossa is the part of this space between the skull base and zygoma. The contents of the masticator space include the temporalis muscle, the ramus of the mandible, divisions of the mandibular nerve (V3) and the internal maxillary artery. The masticator space is closely related to the buccal space anteriorly, parotid space posteriorly, PPS medially, submandibular space inferiorly and the skull base superiorly.

The source of infection in this space is commonly odontogenic (Fig. 6). Mandibular osteomyelitis requires subperiosteal drainage (Fig. 6b). An intra-oral approach at the retromolar trigone is appropriate for draining abscesses medial to the ramus of the mandible. For those located lateral to the mandibular ramus, an extra-oral approach along the inferior border of the mandible is necessary.[1] The masticator space may be secondarily involved as a result of aggressive maxillary sinusitis (Fig. 7). Involvement of the infratemporal fossa necessitates extensive drainage with a larger incision.[12]

Parotid space

Besides the parotid gland and lymph nodes, other contents of this space include the facial nerve, external carotid artery, retromandibular vein, auriculotemporal nerve and superficial temporal artery. Acute parotitis and intraparotid lymphadenitis are the common sources of infection (Fig. 8), which can easily spread to the adjacent PPS (Fig. 4). An external, parotidectomy-

Fig. 6 (a) Axial contrast-enhanced CT image shows an abscess in the left masticator space adjacent to the angle of the mandible (arrow) and swelling of the left masseter. (b) Changes of osteomyelitis secondary to dental caries (arrow) are seen on bone window settings.

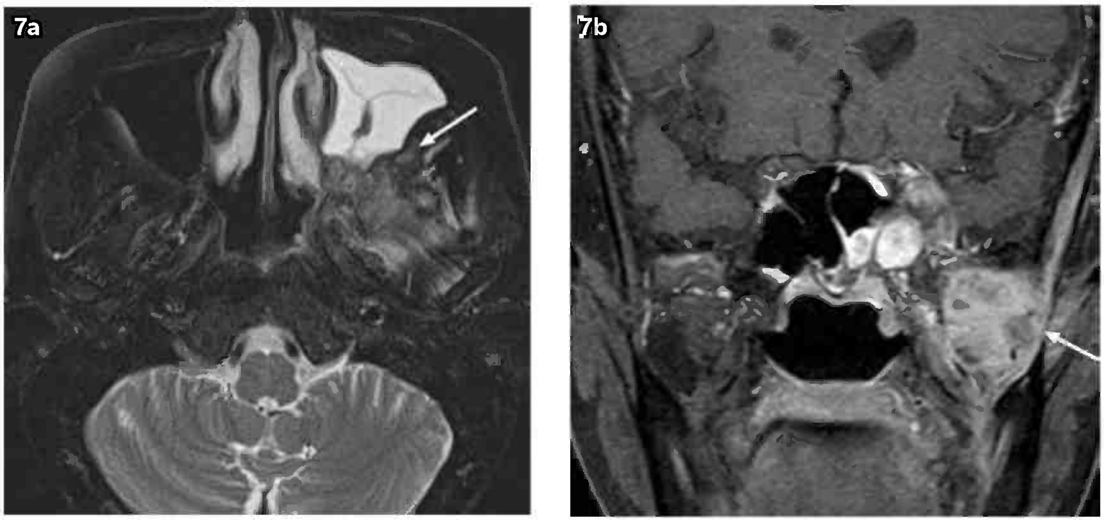

Fig. 7 (a) Axial T2-W MR image and (b) coronal fat-saturated gadolinium-enhanced T1-W MR image in a neutropenic patient with leukaemia show left maxillary fungal sinusitis, which has breached the posterior antral wall (arrow) to involve the masticator space.

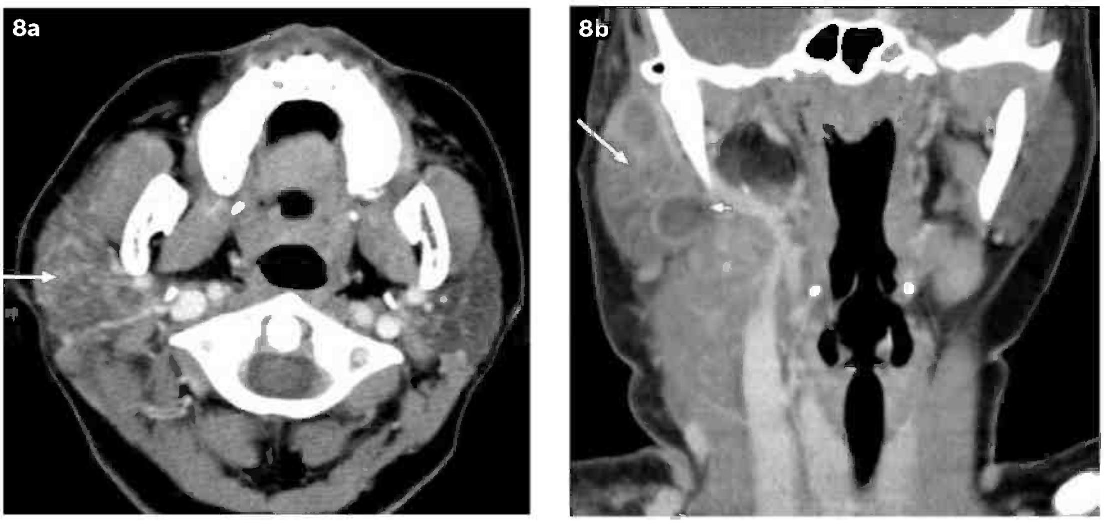

Fig. 8 (a) Axial and (b) coronal contrast-enhanced CT images show an enlarged hyperattenuated right parotid gland (arrow) in keeping with parotitis. A number of necrotic intraparotid lymph nodes are also depicted (arrowhead) with swelling of the adjacent sternocleidomastoid muscle. Histopathological examination revealed tuberculous lymphadenitis.

Fig. 9 Axial contrast-enhanced CT image shows a right-sided peritonsillar abscess obliterating the fat in the right prestyloid parapharyngeal space (arrow). Note that the fat in the left parapharyngeal space is well preserved (arrowhead).

like approach is used to drain a parotid space abscess.[1] Rarely, abscesses may involve the deep lobe of the parotid gland (Fig. 4). These abscesses are drained using an intra-oral approach.

Parapharyngeal space

The PPS is further divided by the tensor – vascular – styloid fascia into pre- and poststyloid components.[13] The cone-shaped prestyloid PPS extends from the base of the skull down to the hyoid bone and contains predominantly fat (Fig. 1). Due to the lack of limiting boundaries, the PPS is secondarily infected from the surrounding spaces (Figs. 3, 4 & 9), and likewise, PPS infection can spread rapidly to other spaces. PPS infections tend to liquefy the fat rapidly, forming large amounts of pus. Hence, active intervention in the form of surgery or image-assisted drainage is usually warranted.[1,13] Abscesses localised to the PPS on the CT image may be accessed via the transoral route for image-guided drainage.[14] Involvement of the poststyloid compartment or other adjacent spaces necessitates an external cervical approach to incision and drainage.

The poststyloid parapharyngeal space, also known as the carotid space (CS), is located posterior to the PPS and extends from the skull base down to the root of the neck. The main content of the CS is the carotid sheath, which contains the carotid artery, internal jugular vein, sympathetic trunk and cranial nerves IX, X, XI and XII. Children are prone to CS infections, which commonly occur secondary to cervical adenitis and are often well-controlled with intravenous antibiotic therapy (Fig. 10).[15] However, complications such as Lemierre's syndrome (an infective internal jugular vein thrombosis), mycotic carotid artery aneurysm, ipsilateral Horner's syndrome and IX–XII cranial nerve palsies may develop in uncontrolled CS infections.[1]

Retropharyngeal and danger spaces

The RPS extends from the skull base into the mediastinum, up to the T2 thoracic vertebral level. The RPS is bordered anteriorly by the buccopharyngeal fascia (middle layer of the deep cervical fascia) and posteriorly by the alar fascia (a

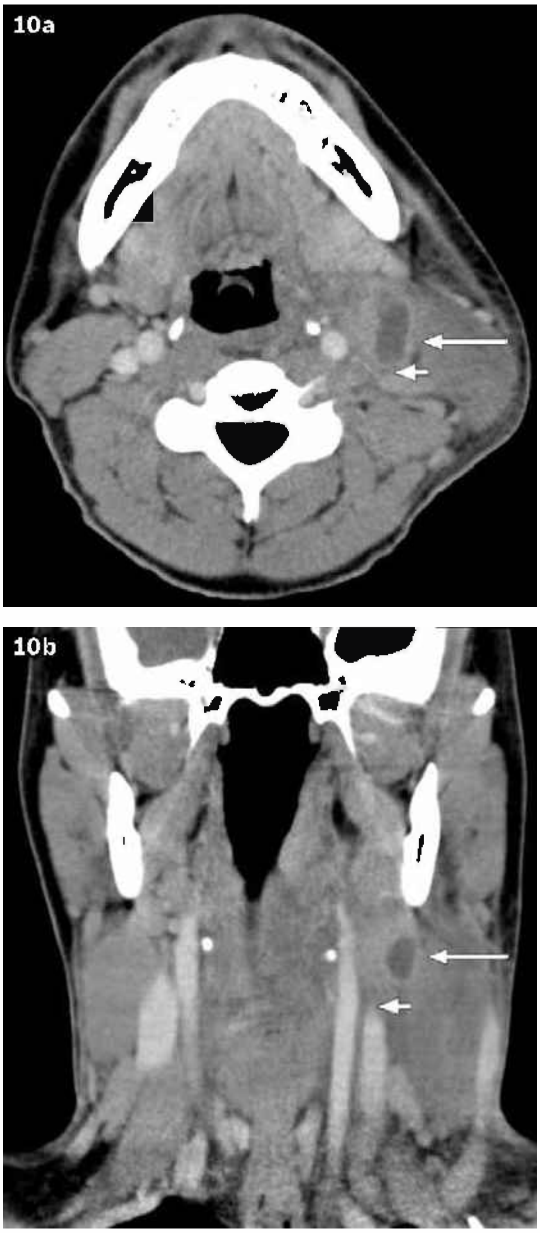

Fig. 10 (a) Axial and (b) coronal contrast-enhanced CT images show suppurative lymphadenitis in the left carotid space (arrow). The internal jugular vein (arrowhead) is compressed.

division of the deep layer of deep cervical fascia), which separates it from the danger space. On imaging, the RPS appears as a thin stripe of fat density posterior to the pharynx (Fig. 2). The differentiation of RPS oedema from RPS abscess on imaging is important, as the former does not require surgical drainage. RPS oedema appears as a smooth expansion of the space by fluid without evidence of an enhancing rim, and is almost always confined to the level of the oropharynx (Fig. 11).[16] It is associated with early infections, internal jugular vein obstruction (thrombosis, compression or resection), a post-radiation state and prevertebral calcific tendonitis; it often regresses spontaneously when the causative factor is treated.[4,16]

The RPS lymph nodes are prominent in young children but involute in late childhood. This explains the prevalence of retropharyngeal abscesses in the paediatric age group, which develop secondary to the suppuration of these lymph nodes

Fig. 11 Axial contrast-enhanced CT image shows non-abscess fluid in the retropharyngeal space (arrow). No mass effect is seen on the adjacent spaces. Note the thrombus (arrowheads) in the left internal jugular vein.

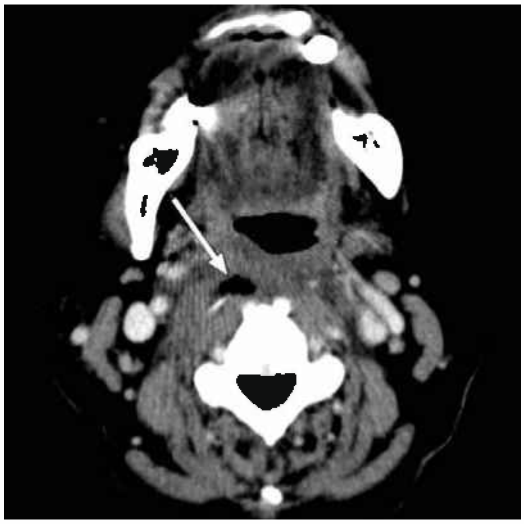

Fig. 12 Axial contrast-enhanced CT image shows a gas-containing abscess in the retropharyngeal space (arrow) containing a fish bone within. Extensive oedema of the retropharyngeal and prevertebral space is seen with mild mass effect on the airway and lateral displacement of the carotid sheath.

following upper respiratory tract infections. In adults, the cause is often traumatic (Fig. 12). Abscesses require drainage and appear typically as rim-enhancing biconvex collections with mass effect, flattening the prevertebral muscles. They tend to displace the carotid sheath laterally and the PPS anterolaterally (Fig. 12). Aggressive airway management is necessary in these patients to avoid airway obstruction and aspiration of pus. The danger space is a potential space, indistinguishable from the RPS on imaging. It lies between the RPS anteriorly and the prevertebral space posteriorly, extending from the skull base to the level of the diaphragm.

Prevertebral space

The prevertebral space lies posterior to the danger space, separated by the prevertebral fascia (a division of the deep layer of the deep cervical fascia) and extends from the base of the skull down to the coccyx (Fig. 2). Infections of this space result from infective spondylodiscitis and penetrating injuries to the posterior pharyngeal wall. Secondary spread from RPS infections is known to occur. Spondylodiscitis often manifests as disc space narrowing and irregular vertebral end plate erosion on plain radiographs and CT imaging (Fig. 13). MR imaging is more sensitive in detecting these changes and delineating epidural phlegmon or drainable empyema.[11] Once identified on imaging, prevertebral space abscesses should be drained using an external cervical approach. The use of an intra-oral approach may lead to the formation of a persistent draining fistula in the posterior pharynx.[1,11]

Anterior visceral space

The anterior visceral space, also termed as the pretracheal space, is bounded by the visceral division of the middle layer of the deep cervical fascia, and lies between the infrahyoid strap muscles and the oesophagus. It contains the thyroid gland, trachea and the anterior wall of the oesophagus, and extends from the thyroid cartilage into the superior mediastinum up to the T4 vertebral level. Infections of the anterior visceral space often originate from traumatic perforation of the anterior oesophageal wall, and less commonly, from neck trauma or thyroiditis. Due to their potential to compromise the airway and cause mediastinitis, aggressive treatment and surgery are often warranted.

Fig. 13 Axial contrast-enhanced CT image shows a rim-enhancing prevertebral abscess (arrow) secondary to infective spondylodiscitis at the C3/4 level. Epidural extension of the abscess is seen (black arrowheads). The vertebral body erosion indicates that the abscess primarily involves the prevertebral space rather than the retropharyngeal space.

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.

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SINGAPORE MEDICAL COUNCIL CATEGORY 3B CME PROGRAMME

(Code SMJ 201205B)

	True	False
Question 1. The extent of the retropharyngeal space is up to the level of:		
(a) C7 vertebra.	☐	☐
(b) T2 vertebra.	☐	☐
(c) T3 vertebra.	☐	☐
(d) Coccyx.	☐	☐
Question 2. The following space is exclusively infrahyoid in location:		
(a) Submandibular space.	☐	☐
(b) Anterior visceral space.	☐	☐
(c) Carotid space.	☐	☐
(d) Danger space.	☐	☐
Question 3. The commonest source of infection in the submandibular space is:		
(a) Odontogenic.	☐	☐
(b) Trauma.	☐	☐
(c) Submandibular sialadenitis.	☐	☐
(d) Spread from adjacent spaces.	☐	☐
Question 4. The following space is predisposed to abscess formation in the paediatric population:		
(a) Retropharyngeal space.	☐	☐
(b) Prestyloid parapharyngeal space.	☐	☐
(c) Prevertebral space.	☐	☐
(d) Masticator space.	☐	☐
Question 5. The following is NOT a feature of retropharyngeal oedema:		
(a) It most commonly occurs at the level of the oropharynx.	☐	☐
(b) It may be associated with internal jugular vein thrombosis.	☐	☐
(c) It does not have an enhancing rim.	☐	☐
(d) It displaces the surrounding carotid space laterally.	☐	☐

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