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REVIEW

A dangerous cause of airway obstruction: deep neck infection

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Abstract

Deep neck infection (DNI) is an infection in the fascial spaces of the neck. Complications of DNI, including mediastinitis, internal jugular vein thrombosis, and upper airway obstruction, are severe and potentially life threatening. Therefore, early identification and accurate management of DNI are essential. We review the anatomy of the deep spaces of the neck to determine the route of DNI spread so that emergency doctors, physicians, and otorhinolaryngologists can quickly recognize the development of lethal complications of DNI, such as asphyxia from airway obstruction.

Keywords

Deep neck infection; Acute airway obstruction; Mortality

1. Introduction

The incidence of deep neck infection (DNI) is increasing, and the mortality of DNI complications remains high [1]. DNI involves the spaces of the neck and can spread from the base of the skull to the mediastinum; however, recognizing the complications, such as acute airway obstruction, remains a clinical challenge [2, 3]. Here we review the location of the deep spaces of the neck and its relationship with the development of the complications of DNI, especially highlight all clinicians to evaluate the airway patency in DNI patients in their practice.

2. Anatomy of the deep neck and the compartmentalization and intercommunicating of the spaces

The muscles, vessels and visceral structures of the neck are enveloped by the cervical fascia, which has superficial and deep components supporting and compartmentalizing the internal structures. The superficial cervical fascia, which lies just below the dermis, completely encloses the head and neck. The deep cervical fascia consists of three layers: investing fascia (superficial layer), pretracheal fascia (middle layer), and prevertebral fascia (deep layer). These layers divide the deep neck into several potential intercommunicating spaces through which pathogens causing DNI can spread. These spaces include the suprahyoid space, infrahyoid space, and the space involving the entire length of the neck [4, 5].

The suprahyoid space is located between the skull base and hyoid bone and comprises peritonsillar, submandibular, masticator, temporal, buccal, parotid, and parapharyngeal spaces. The infrahyoid space located between the hyoid bone and clavicle is the pretracheal space. The space along the length of the neck comprises retropharyngeal, danger, and prevertebral spaces. The danger space lies behind the retropharyngeal space extending from the neck to the mediastinum and provides the most critical route for the contiguous spread of infection between the neck and the chest [6–8].

3. DNI, their spread, and complications

3.1 Peritonsillar abscess (quinsy)

Peritonsillar abscess is one of the most common causes of head and neck abscesses [9]. Common symptoms include severe unilateral sore throat, dysphagia, fever, otalgia, trismus, cervical lymphadenopathy, tonsillar or pharyngeal exudates, uvular deviation toward the unaffected side, and upper airway obstruction [10, 11]. The most common pathogens are beta-hemolytic *Streptococci*, *Staphylococcus aureus*, *Pneumococcus*, and *Haemophilus influenza* [9]. Oral anaerobes, such as *Fusobacterium necrophorum*, can also cause peritonsillar abscess. The infection may extend to parapharyngeal, masticator, and submandibular spaces [9].

Bilateral peritonsillar abscess is rare but carries a great risk of airway obstruction. Difficult intubation due to trismus may lead to mortality that requires professionals giving their attention to deal with. Computerized tomography scan of neck is the diagnostic tool to confirm the disease. Incision and drainage of the pus and systemic antibiotics is essential.

TABLE 1. Mechanisms of airway compromise secondary to deep neck infection.

Causes of airway obstruction	Location of DNI
Suprahyoid space	
Trismus	Peritonsillar abscess
	Masticator space
	Parotid space
	Parapharyngeal space
Mass effect leading to mouth or supraglottic airway narrowing	Peritonsillar abscess
	Submandibular and sublingual space
	Ludwig's angina
	Parotid space
	Parapharyngeal space
Laryngeal edema	Parapharyngeal space
Infrahyoid space	
Compression of the airway	Pretracheal space
Tracheal destruction, infection, and obstruction	
Space along the neck	
Compression of the airway	Retropharyngeal space
Laryngeal spasm	
Abscess rupture into the airway	
Abscess spreads into the retropharyngeal space	Danger space
Abscess spreads into danger and retropharyngeal spaces	Prevertebral space

DNI: deep neck infection.

Interval abscess tonsillectomy that usually done six weeks after the initial treatments should be warranted, when the disease is resistant to the existing management [12, 13].

3.2 submandibular and sublingual space infection

Submandibular and sublingual spaces are separated by the mylohyoid muscle. The space below the mylohyoid muscle is submandibular space, which is further divided into submylohyoid and submental spaces. The sublingual space communicates with the submylohyoid space posterior to the mylohyoid muscle. Ludwig's angina primarily involves submandibular, sublingual, and submental spaces [14]. Moreover, submylohyoid space infection may spread inferiorly to parapharyngeal and paravertebral spaces and then into the mediastinum [15, 16].

3.3 ludwig's angina

Ludwig's angina is a severe diffuse cellulitis and potentially life-threatening infection that begins in the floor of the mouth and rapidly spreads to both submandibular and sublingual spaces bilaterally; this may cause airway obstruction, which is a medical emergency [14]. Low socioeconomic status and poor oral hygiene are associated with odontogenic infections, which can lead to cellulitis of the floor of the mouth. Ludwig's angina is always bilateral and usually caused by infection or pericoronitis of the second and third mandibular molars. Patients present with fever, pain, and swelling of the floor of the mouth that pushes the tongue to the roof of the mouth, potentially leading to dysphagia and airway obstruction. Emergency imaging is necessary to assess airway patency. Immediate empirical antibiotics against pathogens, including *Streptococcus* species, and effective airway management may prevent the development of life-threatening complications [17].

3.4 Masticator space infection

The masticator space comprises masseteric, pterygoid, and temporal spaces. Infection of these spaces frequently extends from the molar teeth (especially the third molars). A fluctuant mass is not a prominent finding because the infection is located deep in large muscle masses. However, the clinical hallmark of masticator space infection is trismus (inability to open the jaw) and pain in the body or ramus of the mandible, which may lead to difficult airway management [18].

3.5 Parotid space infection

Parotid space infection is common in debilitated elderly individuals with dehydration, especially in those with diabetes, undergoing surgery, or with endotracheal intubation. Compared with masticator space infection, acute suppurative parotitis manifests with a sudden unilateral tender erythematous mass. The mass could extend from the cheek to the angle of the jaw, leading to trismus [19]. Acute suppurative parotitis can be caused by a calculus (sialolith) or various bacteria and viruses, most commonly *Staphylococcus aureus* and anaerobic

bacteria. When pressure is applied over the parotid gland, the purulent discharge can be expressed through the Stenson duct. Parotid space abscess may rupture or directly extend into the danger or visceral space that invades the posterior mediastinum [8].

3.6 Parapharyngeal space infection

The inverted-cone-shaped parapharyngeal space (also known as pharyngomaxillary space) is located in the lateral aspect of the neck, with its base at the skull and its apex at the hyoid bone. Tonsillitis, odontogenic infection, masticator space infection, parotitis, otitis, pharyngitis, and mastoiditis may spread contiguously and lead to parapharyngeal space infection. Patients with parapharyngeal space infection usually present with fever, trismus, dysphagia, swelling in the submandibular triangle, and medial displacement of the lateral pharyngeal wall. The posterior compartment of the parapharyngeal space contains cranial nerves VIII, X, and XII; carotid sheath; and the cervical sympathetic trunk. Infection of the posterior compartment is potentially lethal because it can result in septicemia, internal jugular vein thrombosis (Lemierre syndrome), internal carotid artery erosion, and laryngeal edema. Parapharyngeal abscess and sudden-onset laryngeal edema can lead to acute airway obstruction; therefore, close observation for urgent airway management is critical [20].

3.7 Lemierre syndrome

Lemierre syndrome, also known as postanginal sepsis, is a lateral pharyngeal space infection extending to the carotid sheath, which leads to suppurative jugular thrombophlebitis. It commonly affects healthy young adults who present with fever, tenderness, and dysphagia due to swelling of the lateral pharyngeal wall. It should be strongly suspected in patients with pharyngitis; septic pulmonary emboli; palsy of cranial nerves X, XI, or XII; and persistent fever despite antibiotic therapy [21]. Anaerobic *Streptococci*, *Prevotella* species, and *Fusobacterium necrophorum* are normal oropharyngeal flora, but they are common pathogens in Lemierre syndrome.

3.8 Pretracheal space infections

The pretracheal space is enclosed by the anterior layer of the pretracheal fascia extending laterally and the posterior layer of the pretracheal fascia extending inferiorly to the superior mediastinum. The pretracheal fascia encircles the trachea and esophagus. Patients with pretracheal space infections may develop hoarseness, dysphagia, and severe dyspnea. Prompt surgical drainage is critical, especially in patients presenting with symptoms and signs of airway compromise [22]. Notably, endotracheal intubation can rarely cause pretracheal space infections, leading to tracheal obstruction [23]. Careful airway management during tracheal intubation is required in all patients.

3.9 Retropharyngeal space infection

The retropharyngeal space is situated behind the hypopharynx and esophagus, which extends inferiorly into the superior mediastinum until the T1-T2 level. It communicates laterally with the parapharyngeal space. The complications of retropharyngeal space infection include hemorrhage, airway compression, asphyxiation resulting from spontaneous abscess rupture into the airway, and laryngeal spasm; these complications can be life threatening because of the risk of acute respiratory failure [24, 25].

3.10 Danger space infection

The danger space lies immediately posterior to the retropharyngeal space and descends from the base of the skull directly into the posterior mediastinum to the level of the diaphragm (T11-T12). It is the pathway for the rapid spread of pathogens from the neck to the chest [26]. Danger space infection contagiously spreads, resulting in retropharyngeal abscess and potentially leading to airway obstruction.

3.11 Prevertebral space infections

The prevertebral space lies immediately posterior to the danger space around the spinous processes and encircles the splenius, erector spinae, and semispinalis muscles and is anteriorly bound by the prevertebral fascia. Compared with parapharyngeal and danger spaces, prevertebral space extends from the base of the skull to the coccyx, allowing infections to spread along the space to the psoas muscle sheath [26, 27].

4. Discussion

Patients with DNI having the complication of mediastinitis, internal jugular vein thrombosis, or necrotizing fasciitis have a high mortality rate and should be treated on an emergency basis [28]. DNI can also cause acute cause upper airway obstruction and sudden-onset asphyxiation, which are life-threatening conditions [29]. Therefore, all patients with DNI should be evaluated for airway patency. Early diagnosis is critical to prevent acute airway obstruction at emergency department. However, maintenance of an adequate airway remains challenging and depends on the mechanism leading to airway obstruction from DNI (Table 1) [7, 11, 15, 25].

The clinical presentation of DNI varies and depends on its infectious origin-for example, local pain from the infection of the mandibular teeth, tonsils, parotid gland, deep lymph nodes, middle ear, and sinuses [30–32]. Irrespective of whether the source of DNI is odontogenic, oropharyngeal, otogenic, or sinogenic, all DNI can extend to the deep neck spaces, resulting in complications [33, 34]. Therefore, they share some typical clinical features, including odynophagia, local swelling in the face and neck, trismus, and dyspnea [4], which are the signs of the complicated course, necessitating aggressive treatment to reduce the risk of mortality of DNI [9, 33–35].

DNI involves in all ages. The majority are adult patients in the thirties or forties. The clinical presentations of DNI in the pediatrics are a distinct entity. Children have predominant lymph nodes. The most common antecedent illness of DNI in the pediatric patients was lymphadenitis, which is less common in adult patients. DNI less frequently extends below the hyoid bone in pediatric patients than in adults. Abscesses in children younger than one year, compared to the other ages, more frequently affects anterior or posterior triangles

than submandibular, submental regions, retropharyngeal, or parapharyngeal angles, and *Staphylococcus aureus* is the most common pathogens. In contrast, polymicrobial infection with group A *Streptococcus* along with anaerobes is the major pathogens in adult patients. Besides, tracheostomy was less frequently required for treatment in children than in adult patients [36–38].

The inflammatory response to DNI leads to complications. The clinical signs of the complications are the manifestation of a difficult airway in patients with DNI. Local swelling that compresses the esophagus and airway can cause odynophagia, dysphagia, and dyspnea. A mass may be not readily visible or palpable externally, because the dense structure of the cervical fascia may hide the mass, or the location of the DNI is hidden by the neighboring organs, such as the trachea, esophagus, and vertebrae [16, 39, 40]. Palpation of the oral cavity, leukocytosis, C- reactive protein levels, arterial blood gas analysis, direct laryngoscopy, neck computed tomography, and neck magnetic resonance imaging are recommended in identifying the mass [24–26, 39–41]. To find the collection of deep pus due to DNI, a pitting appearance, focal tenderness, or a doughy feeling are the characteristic signs by firm deep palpation. Besides, pain or fluid collection affecting the muscles of mastication (the masseter and pterygoid) or impairing the motor branch of the trigeminal nerve can limit maximal mouth opening can lead to trismus [42]. Presence of laryngeal edema, laryngeal spasm, loss of consciousness, or stridor is indicative of airway crisis and a difficulty in trachea intubation that requires tracheostomy [20, 25, 43].

Beside, comorbidities increase the risk of complications of DNI. Risk factors include diabetes mellitus, dental infection, obesity, chronic renal and hepatic disease, old age, drug abuser, congenital neck cysts, and autoimmune disease. For example, patients with DNI and end stage renal disease are associated with poor survival outcomes [44]. Patients with DNI and diabetes or with an increase in body mass index are associated with higher rate of multispace spread of infection and higher possibilities of acute airway obstruction [45, 46].

Effective treatment of DNI depends on the early recognition, appropriate use of parenteral antibiotics, formal surgical drainage of the infection, and securing the airway.

The choice of antimicrobial agents depends on the pathogens. Obtaining cultures before empirical antibiotic treatment is mandatory in DNI patients. The microorganisms isolated in patients with DNI were aerobic and anaerobic pathogens of pharyngeal flora, such as Streptococcus pyogenes, Staphylococcus aureus, Streptococcus viridians, Streptococcus anginosus, Hemophilus influenza, Peptostreptococcus, Fusobacterium species, Provetella species [47]. Therefore, the antibiotic choice for DNI must include agents with spectrum of activity against both aerobic and anaerobic pathogens, including penicillin, amoxicillin/clavulanic acid, ampicillin/sulbactam, clindamycin and metronidazole. piperacillin/tazobactam, third generation cephalosporin along with metronidazole, or carbepenems in more serious clinical conditions [48].

Early and aggressive surgical drainage of the fluid collection from infection is required for DNI. Unilateral and bilateral cervicotomy, or less invasive video-assisted thoracic surgery with or without combination with catheter drainage are crucial to reduce the morbidity and mortality [49]. Vaccum-assisted closure system have been proved useful in the treatment of DNI and descending necrotizing mediastinitis [48]. Besides, successful treatment of DNI by trans-oral or tans-nasal drainage is also reported in previous study [51]. Compared to external approaches, endoscopic approaches have many important advantages, including minimal invasion and complications, absence of cervical scarring, and a short operation time.

Securing the airway in patients undergoing surgical intervention for the management of DNI is still challenging because they usually have limited mouth opening, airway distortion, tissue edema, or cervical immobility [29, 52, 53]. It is critical to assess the risk of a potentially difficult airway and prepare the most appropriate airway management method [41]. Video laryngoscopy and fiberoptic bronchoscopy provide a good real-time visualization of the remaining airway, thus helping in the intubation of the distorted airway of patients with DNI [54, 55]. For patients with DNI and limited mouth opening, transnasal intubation with the guidance of a flexible fiberoptic bronchoscope may be attempted [55, 56]. Tracheostomy is life-saving and early tracheostomy is recommended when massive upper airway edema potentially leading to a compromised airway, or a complicated clinical course without response to the initial treatment [57, 58].

5. Conclusions

Prompt diagnosis and optimal treatment are keys to reducing the mortality associated with DNI. Patients with extended space abscess, retropharyngeal space abscess, and Ludwig's angina need close attention to prevent and resolve the life-threatening complication of airway obstruction. Multidisciplinary treatment for DNI, including early diagnosis, appropriate antibiotic therapy, proper airway management, and adequate surgical intervention, is paramount [59].

AUTHORS' CONTRIBUTIONS

All authors read and approved the final manuscript.

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CONFLICT OF INTEREST

The authors declare they have no conflict of interest.

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