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REVIEW ARTICLE

Deep Neck Space Infections in Children: Has Anything changed?

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ABSTRACT

The diagnosis and management of pediatric deep neck infections (DNIs) has changed over the last three decades. Improvements in imaging techniques, antibiotics and airway management have resulted in a significant decrease in the overall morbidity and mortality.

Knowledge of clinical features of DNIs in children is important because these uncommon infections may be associated with airway compromise or complications due to involvement of contiguous vital structures. Most often, these infections are due to Gram-positive organisms but polymicrobial infections are also well described. There is no consensus on management, with some authors advocating an aggressive surgical approach and others favoring a trial of medical management prior to surgical intervention. Surgical management is often indicated in young children, large abscesses, or those complicated by extension to critical structures. Once the source of the abscess or DNI is controlled and purulent collections drained, antibiotic therapy can often be transitioned to an oral agent, provided there is evidence of clinical improvement.

Keywords: Abscess, Deep neck infection, Lemierre syndrome, Mediastinitis, Odontogenic, Parapharyngeal, Peritonsillar, Retropharyngeal, Suppurative lymphadenitis.

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INTRODUCTION

According to the most recent Kids Database, the prevalence of deep neck infections (DNI) was 3,444 in 2009, with an estimated incidence of 4.6 per 100,000 children.[1] Deep neck infections can occur as a result of suppuration of deep cervical nodes, arise from specific anatomic sources such as odontogenic infection or less often from vertebral osteomyelitis. Fundamental to the understanding of DNIs, their etiology and possible complications is the relationship of cervical anatomic spaces and fascial planes.

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CERVICAL FASCIAL SPACES

The cervical fascia divides the neck into a collection of spaces. The cervical fascia is divided into a superficial and a deep fascia. The superficial fascia extends from the superior aspect of the head down to the shoulders, axilla, and thorax and includes the superficial musculoaponeurotic system. The area contained within this space is not considered a deep neck space. The deep cervical fascia contains three layers, the superficial, middle and deep layers. The framework of the cervical fascial planes forms at least 11 deep neck spaces. Deep neck spaces are often classified into three groups based on their relationship to the hyoid bone. The spaces superior to the hyoid are the parapharyngeal, submandibular, parotid, masticator, and peritonsillar spaces. Inferior to the hyoid is the anterior visceral space, which is also called pretracheal space. Then there are the retropharyngeal, "danger" space and prevertebral spaces, which extend throughout the length of the neck.

CLINICAL MANIFESTATIONS OF DNIs

The presenting signs and symptoms are determined by the location and contents of the affected space.[2] Infectious processes can spread easily within the fascial space where the disease originates, but can also extend as disease progresses into neighboring spaces. Extension of infection into the spaces that extend the length of the neck can spread disease far beyond its origin and thus cause life-threatening complications.[3-5] For the purpose of this article, we have described the signs and symptoms based on the deep space affected (Table 1). However, the physical exam and workup for a DNI in a pediatric patient should be based on sound clinical principles taking into account that signs and symptoms may vary depending on the location.

The evaluation of a child with a suspected DNI requires a detailed history, physical examination, laboratory studies, and in some cases diagnostic imaging. Unlike uncomplicated superficial neck infections in DNIs, ionizing radiation is sometimes necessary due to the difficulty in identifying the precise location and extent of the infection. It is important to take into account the overall

Table 1: Signs and symptoms of deep neck infections

Location	*Symptom*
Submandibular[1,5]	Fever Swelling Induration Elevation of floor of mouth Muffled voice
Peritonsillar[1,4]	Fever Sore throat Dysphagia Odynophagia Muffled voice Ear pain Drooling
Parapharyngeal prestyloid[5,20]	Fever Chills Neck pain Trismus Anteromedial displacement of tonsil Pain with movement toward opposite side
Parapharyngeal poststyloid[5,20]	Same as prestyloid but more subtle No trismus Carotid sheath complications possible – Internal jugular vein thrombosis Carotid aneurysm Horner's syndrome IX–XII palsy
Retropharyngeal[5]	Neck pain Fever Irritability Dyspnea Noisy breathing/snoring
Masticator[5]	Trismus Sore throat Dysphagia Preauricular swelling
Buccal[5]	Cheek swelling
Parotid	Swelling of pre- and postauricular area Trismus Dysphagia Systemic symptoms
Pretracheal	Swelling Sore throat Dysphagia Hoarseness Dyspnea

state of the patient and to perform imaging based on the As Low As Reasonably Achievable (ALARA) principles for minimizing radiation doses. In the history of present illness, it is important to obtain data regarding the age of the child and the duration of illness. It is important to identify associated symptoms involving the airway, respiratory distress, and the presence of symptoms suggestive of a rapidly progressive disease process. It is helpful to determine if there has been a change in size or consistency (firm *vs* soft) of the mass and the timing of these changes. The presence of fever, pain, trismus odynophagia, and limitation of cervical range of motion all indicate more severe infection. It is also important to obtain an exposure history such as animal contacts, specifically with kittens or cats, close contact with anyone at risk for tuberculosis, or with a recent history of methicillin-resistant *Staphylococcus aureus* (MRSA).[6]

On physical examination, careful inspection of the oral cavity including floor of the mouth, teeth, gums, oropharynx should be performed to determine a possible source of lymphadenitis and for a potential airway compromise. The neck should be inspected for asymmetries and if identified the neck mass should be measured and the location (midline or lateral) documented. The surgeon should look for the presence of an overlying discoloration, sinus or fistula, tenderness, palpable consistency (i.e., soft or firm), and its mobility for clues of the underlying etiology. However, a high index of suspicion must be maintained since children with a DNI can present with generalized malaise, fever, neck pain or torticollis without a palpable mass, associated erythema and edema. In other cases, a peritonsillar or parapharyngeal abscess may present with trismus and odynophagia. Understanding the important vascular and neural structures contained in specific neck spaces can help determine the affected site and location of the infection helping determine the adequate diagnostic imaging test. This is especially true for cranial neuropathies, which can provide localizing information. In children with a suspected DNI, one must assess for airway patency. This is extremely important if diagnostic imaging is going to require sedation. Given the smaller airway caliber in pediatric patients, if there are any signs of respiratory distress the airway must first be secured prior to proceeding with sedation. It is key to remember that the presence of airway obstruction changes the management algorithm: secure the airway prior to proceeding with the diagnostic evaluation and surgical management. A flexible laryngoscopy may be warranted as part of the physical exam to evaluate the airway in case of respiratory distress. If the airway compromise is significant, it may require intubation or tracheostomy depending on the severity of the obstruction prior to addressing the infectious process.[4] Sublingual space infections can progress rapidly and are more likely to develop airway obstruction due to location of infection.

In some cases, local signs and symptoms may be nonspecific but rapidly progressive with significant systemic signs of sepsis as is common in fusobacterial infections, such as Lemierre's disease or some cases of necrotizing fasciitis. Patients may require intensive care management and airway control due to development of septic shock.[7]

Following a thorough history and physical examination, additional diagnostic studies and ancillary laboratory testing may be needed prior to surgical intervention. The remainder of the physical examination may provide

additional clues as to the etiology of an inflammatory neck mass, systemic illness, or immunocompromise.

DIAGNOSTIC IMAGING

Diagnostic imaging is often necessary to assist with the diagnosis of DNIs. Knowing what imaging modality to choose is of utmost importance due to the depth of these infections and the vital structures that can be affected. It can help distinguish a defined abscess from inflammatory lymphadenitis. In pediatric patients where ionizing radiation is a concern, ultrasound can be especially helpful in differentiating cellulitic processes from abscesses. Ultrasound does have limitations especially when it comes to surgical planning as it does not provide the surgeon a roadmap for the procedure. Ultrasound has been recommended recently for the diagnosis of peritonsillar and some parapharyngeal infections but its widespread use is still limited.[8] Computed tomography (CT) with contrast can provide additional information about the extent of disease, especially when it spreads into adjacent areas or when a complication such as venous thrombosis or mediastinitis is supected. Using CT with contrast to better locate the presence of a mature abscess collection can also assist with surgical planning. One of the more recent advances in diagnostic imaging is the ability to obtain better quality images while achieving reductions in the amount of radiation. For example, in one study, low tube voltage 80 kVp neck CT provided increased abscess delineation, with less radiation, in patients with a peritonsillar abscess compared with 120 kVp neck CT.[9]

Magnetic resonance imaging is also an option, but requires general anesthesia in pediatric patients and is not a first option. It has a role in exploring the extent of potential vascular complications or spread of disease to important structures.

Lateral neck radiographs are sometimes obtained if the suspected DNI is a retropharyngeal abscess. In this case, the lateral neck X-ray will reveal widening of the retropharyngeal space and may also show an air fluid level in case of an abscess. The normal measurements at the level of C3 from the anterior surface of the vertebrae to the posterior border of the airway should be 6 mm or less. At C6, this distance should be 14 mm or less.[10]

ADJUVANT LABORATORY TESTING

Aside from diagnostic imaging, it is important to obtain a complete blood count with differential. In cases of bacterial infection, there will be leukocytosis with an increase in number of neutrophils and an elevated band count. C-reactive protein and blood cultures should be done when bacteremia is suspected. Blood urea nitrogen and creatinine should be obtainied preceding diagnostic imaging requiring intravenous contrast. In cases of sepsis where disseminated intravascular coagulation is suspected on the basis of the clinical presentation, a screen (i.e., prothrombin time, activated partial thromboplastin time, fibrin split products, and fibrinogen) should be obtained.

In some cases, an erythrocyte sedimentation rate may be necessary to help distinuguish other possible etiologies like Kawasaki disesase, which may present initially as a DNI.

PATHOPHYSIOLOGY OF DNIs

Deep neck lymphadenitis is associated with a variety of pharyngeal, dental, skin, or other head and neck infections. Cervical adenitis is commonly the source of pediatric DNIs. Microorganisms penetrate the mucosal surfaces of the respiratory track and are cleared via lymphatic vessels to regional lymph nodes. In lymph nodes, as a response to invasion of bacterial pathogens, T-cell proliferation leads to node enlargement and neutrophil recruitment which in turn leads to a suppurative lymph node. Suppurative lymphadenitis may progress to abscess formation as the host defenses attempt to prevent the infection from spreading. Although most cervical lymphadenopathy in pediatric patients is viral in etiology, suppuration of an inflammed lymph node is suggestive of a bacterial infection. Among the most common pathogens in DNIs are group A streptococcus and other streptococci, *S. aureus* or anaerobes. However, many of these infections are polymicrobial as outlined in Table 2.

Table 2: Most common pathogens in deep neck infections

Location	*Pathogens*
Submandibular space[5]	*Streptococcus viridans* *Staphylococci* *Prevotella* *Peptostreptococcus*
Peritonsillar[11,13]	*Streptococcus pyogenes* *Fusobacterium necrophorum* *Prevotella oris* *Streptococcus viridans*
Parapharyngeal[3,11]	*Polymicrobial* *Streptococcus pyogenes* *Staphylococcus aureus* *Haemophilus influenza* *Prevotella* *Porphyromonas* *Fusobacterium* *Peptostreptococcus*
Retropharyngeal[5]	*Polymicrobial* *Streptococcus viridans* *Staphylococcus* *Streptococcus*
Masticator[5]	*Streptococcus aureus*
Buccal[5,19]	*Peptostreptococcus* *Bacteroides* *Prevotella*

ANTIMICROBIAL THERAPY

Depending on the location of the suspected infection and the overall state of the patient, empiric antimicrobial therapy is initiated as further workup progresses. Medical treatment for suspected bacterial lymphadenitis generally begins with empiric antibiotic therapy directed at the common organisms, *S. aureus* and group A streptococci. Unlike superficial bacterial lymphadenitis, DNIs tend to be polymicrobial. The most commonly used antibiotics include clindamycin and ampicillin sulbactam for peritonsillar, retropharyngeal, and parapahryngeal infections. If an odontogenic source is suspected, penicillin G with metronidazole or clindamycin are good alternatives.[11] For a lateral neck infection in patients younger than 2 years where *S. aureus* is the most common pathogen, cefazolin and nafcillin are the therapy of choice. In areas with a high prevalence of MRSA, clindamycin or vancomycin would be required.[12] It is important to consult with infectious disease specialists regarding appropriate treatment regimens since these infections can be polymicrobial and in some cases uncommon pathogens can be isolated. Rapid identification of organisms can be achieved using ribonucleic acid microarrays, which can help guide antibiotic therapy.[13] They can also provide great assistance in determining the duration of intravenous antibiotic therapy and the transition to oral antibiotic at the time of discharge from hospital. The duration of treatment is often related to the severity of the infection and the presence of complications.

SURGICAL INTERVENTION

Incision and drainage should be considered in patients who do not respond to empiric antimicrobial therapy. After obtaining imaging and depending on the location of the abscess, an intraoral or external approach may be most suitable. In a recent study by Adil et al, patients who were drained surgically had a 22% longer length of stay (mean = 4.19 days) than those who were managed without surgery (mean = 3.44 days). The mean hospital charges for patients who were drained surgically were almost twice as much as those who were managed medically ($28,969 *vs* $17,022).[1] The surgical approach is determined by the location of the abscess and its relation to important surrounding structures. Rim enhancement in diagnostic imaging, younger age and an elevated white blood corpuscles have been associated with the presence of purulent material at time of incision and drainage.[10] Peritonsillar space, retropharyngeal and parapharyngeal abscesses often require an intraoral surgical approach. Retropharyngeal space infections that are close to the skull base often require a trial of antibiotic therapy since they may be hard to reach surgically and demand careful monitoring for progression.[14] In peritonsillar abscesses, needle aspiration is a widely accepted therapy. In patients with larger abscesses, a more invasive approach, such as intraoral incision and drainage may be warranted. One of the most important advances in the management of DNIs is the use of interventional radiology to assist in the treatment of infections in hard to reach locations, which would otherwise result in significant morbidity.[15] Interventional radiology has been successfully employed to access mediastinal extension of abscesses as well as infections in close proximity to the skull base and the major vessels.[16] In cases of mediastinal extension, consultation with thoracic surgery should be pursued. Current management of mediastinal abscesses has shifted over the last decade toward video-assisted thoracoscopic surgery avoiding a thoracotomy.[18] If an odontogenic source is suspected, dental extraction by oral maxillofacial surgeons is needed to eliminate the source of the infection.[19]

COMPLICATIONS OF DNIs

Deep neck space infections in pediatric patients can result in significant complications due to local spread or involvement of the vital structures contained within the neck spaces. In a recent series of pediatric patients identified with DNIs, 4.8% had complications.[1] The most common complications were sepsis and respiratory failure. Other series have described mediastinitis and airway obstruction as the most common complications. Mediastinitis can occur due to downward extension of an infection involving the anterior visceral neck or the danger space. Acute mediastinitis is associated with high mortality rates ranging from 12 to 50%.[3,20,21] Treatment may require prolonged antibiotics and surgical or interventional radiology procedures to drain the abscess.

Immunocompromised patients can present with severe infections such as necrotizing fasciitis often with a very subtle presentation. Therefore, a high degree of suspicion is necessary with any neck infectious process in this patient population.[3] Treatment of necrotizing fasciitis will require intensive care unit monitoring with parenteral antibiotics as well as frequent surgical debridements. Necrotizing fasciitis can also occur in patients with poor dentition, usually in adults.

Ludwig's angina is a bilateral submandibular space infection involving the sublingual and submylohyoid spaces. It is usually from an odontogenic source and more common in adults since it originates from periapical abscesses from the second or third mandibular molars. With aggressive airway management, surgical debride-

ment and antibiotic therapy, the mortality of Ludwig's angina has decreased to less than 10%.[22]

Recurrent infections of the visceral space involving the thyroid gland should be suspected for the presence of a fourth branchial cleft cyst. Pathogens involved with this condition usually involve the oral cavity flora.[23] Infections in the prevertebral and spinal space can result in significant neurologic deficits due to cord compression. Rates of paralysis, which is often irreversible, have been reported in 4 to 22% of patients.[10]

Infections in the parapharyngeal space can lead to life-threatening complications such as laryngeal edema, sudden death due to vagal involvement, Lemierre syndrome, and carotid artery erosion. Lemierre syndrome is the most common vascular complication in the parapharyngeal space. It is an occlusive septic thrombus of the internal jugular vein, associated with metastatic foci of infection most commonly to the lungs. Complications related to retropharyngeal space abscesses can include acute airway obstruction especially in younger children (Figs 1 and 2). Abscesses in this location can also rupture and result in aspiration of purulent contents, fulminant pneumonia, and death.

CONCLUSION

The diagnosis and management of pediatric DNIs has continued to evolve. Improvements in imaging techniques with emphasis in minimizing the dose of radiation, antibiotic stewardship, and airway management have resulted in a significant decrease in the overall morbidity and mortality. It is, however, still important to understand the anatomic relations and clinical features of DNIs because these uncommon infections may be associated with airway compromise or complications due to involvement of contiguous vital structures.

Fig. 1: Intraoperative image of a retropharyngeal abscess extending inferiorly to the posterior aspect of the larynx at the time of laryngoscopy to secure the airway

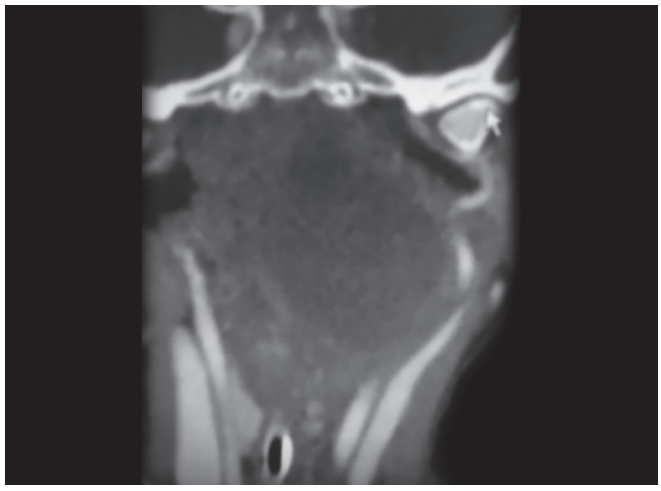

Fig. 2: Computed tomographic scan image of a large retropharyngeal abscess extending into parapharyngeal space causing vascular compression

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