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ANATOMY OF THE CERVICAL FASCIA

The fibrous connective tissue that constitutes the cervical fascia varies from loose areolar tissue to dense fibrous bands. This fascia serves to envelope the muscles, nerves, vessels and viscera of the neck, thereby forming planes and potential spaces that serve to divide the neck into functional units. The cervical fascia functions to both direct and limit the spread of disease processes in the neck and therefore a sound knowledge of the fascial layers is essential to understanding the presentation, treatment and potential complications of infections in the neck.

The cervical fascia was first described by Burns in 1811 and in the ensuing years was the subject of much controversy. As summarized by Malgaigne, a French anatomist, "the cervical fascias appear in a new form under the pen of each author who attempts to describe them." In reality, for the past several thousand years, head and neck anatomy has not significantly changed, so that it is not so much the anatomy that is confusing as it is the various terminology used to describe the anatomy. It is now generally agreed upon that the cervical fascia can be divided into a simpler superficial layer and a more complex deep layer that is further subdivided into superficial, middle and deep layers.

The superficial layer of cervical fascia ensheaths the platysma in the neck and extends superiorly in the face to cover the mimetic muscles. It is the equivalent of subcutaneous tissue elsewhere in the body and forms a continuous sheet from the head and neck to the chest, shoulders and axilla.

The superficial layer of the deep cervical fascia is also known as the investing layer, the enveloping layer, the external layer and the anterior layer of the deep fascia. It has been described using the "rule of twos"—it envelops two muscles, two glands and forms two spaces. This layer originates from the spinous processes of the vertebral column and spreads circumferentially around the neck, covering the sternocleidomastoid and trapezius muscles. In

the midline, it attaches to the hyoid and continues superiorly to enclose the submandibular and parotid glands. Here it also covers the anterior bellies of the digastrics and the mylohyoid, thereby forming the floor of the submandibular space. At the mandible, the fascia splits into an internal layer, which covers the medial surface of the medial pterygoid to the skull base and an outer layer that covers the masseter and inserts on the zygomatic arch. The two spaces it forms are the space of the posterior triangle on either side of the neck and the suprasternal space of Burns in the midline.

The middle layer of the deep cervical fascia is also known as the visceral fascia, the prethyroid fascia and the pretracheal fascia. It can be thought of in two subdivisions, the muscular division, which surrounds the infrahyoid strap muscles, and the visceral division, which envelops the pharynx, larynx, esophagus, trachea, and thyroid gland. The superior extent of the muscular division is the hyoid and thyroid cartilage, inferiorly it inserts on the sternum and clavicle. The visceral division passes inferiorly into the upper mediastinum where it is continuous with the fibrous pericardium and covers the thoracic trachea and esophagus. The antero-superior extent of the visceral division is the hyoid and thyroid cartilage, while posteriorly this fascia covers the buccinator and the pharyngeal constrictors to the skull base—this portion is also called the buccopharyngeal fascia.

The deep layer of the deep cervical fascia originates from the spinous processes of the cervical vertebra and the ligamentum nuchae. At the transverse processes of the cervical vertebra, it divides into an anterior alar layer and a posterior prevertebral layer. The alar fascia extends from the base of the skull to the second thoracic vertebra, where it joins the visceral fascia. It lies between the visceral layer of the middle fascia and the prevertebral layer. The prevertebral fascia lies just anterior to the vertebral bodies and extends the entire length of the vertebral column. It travels circumferentially around the neck and covers the vertebral muscles, the deep muscles of the posterior triangle of the neck and the scalene muscles. This layer of fascia surrounds the brachial plexus and subclavian vessels and continues laterally as the axillary sheath.

The carotid sheath is a fascial layer that is associated with but is anatomically separate from the previously described layers. It receives contributions from all three layers of deep cervical fascia and contains the carotid artery, internal jugular vein and vagus nerve. It continues from the skull base through the neck along the anterior surface of the prevertebral fascia, and enters the chest behind the clavicle (1,2,3).

ANATOMY OF THE DEEP NECK SPACES

The various layers of cervical fascia, as they pass around and attach to structures in the neck, form several potential spaces. The hyoid is the most important structure that limits the spread of infection in the neck and is the most reliable landmark when performing surgery for deep neck abscesses. Therefore, when studying these spaces, it is reasonable to group them according to their relationship to the hyoid into three categories—spaces involving the entire length of the neck, suprahyoid spaces and infrahyoid spaces.

Spaces Spanning the Entire Length of the Neck

The superficial space is located between the superficial fascia and the superficial layer of the deep fascia. This potential space lies superficial and deep to the platysma and contains loose areolar tissue, lymph nodes, nerves and vessels—the most significant of which is the external jugular vein. The loose areolar tissue provides the dissection plane for raising subplatysmal skin flaps. This space is most commonly involved with superficial cellulitis of the neck, but if abscess formation does occur, diagnosis is not difficult as this will present with obvious fluctuance, erythema, warmth and tenderness. A superficial space abscess can be approached with a transverse incision within Langers lines in the area of prominence, followed by evacuation of purulent material, local wound care and appropriate antibiotic therapy.

The deep neck spaces that run the entire length of the neck include the retropharyngeal space, the danger space, the prevertebral space and the visceral vascular space. The retropharyngeal space is also known as the posterior visceral space, the retrovisceral space and the retrosophageal space. It occupies the space posterior to the pharynx and esophagus. Its anterior wall is made up of the buccopharyngeal fascia superiorly and the visceral division of the middle fascia inferiorly, the posterior wall is the alar layer of the deep fascia, and the lateral boundary is the carotid sheath. This space extends from the base of the skull to the level of the first and second thoracic vertebra, where the fascial layers making up its walls join together.

Posterior to the retropharyngeal space lies the danger space, so named because it contains loose areolar tissue and offers little resistance to the spread of infection. It is the space between the alar layer and prevertebral layer of the deep fascia and runs from the skull base to the diaphragm.

The prevertebral space is limited anteriorly by the prevertebral fascia, laterally by the attachment of this fascia to the transverse processes and posteriorly by the anterior longitudinal ligament, the vertebral bodies and the deep musculature. It extends the entire length of the vertebral column. Infection in this space tends to stay somewhat localized due to the dense fibrous attachments between the fascia and the deep muscles.

The visceral vascular space is the potential space within the carotid sheath. Like the prevertebral space the visceral vascular space is quite compact, contains little areolar tissue and is resistant to the spread of infection. However, it was not termed the “Lincoln’s highway” of the neck for no reason. It extends from the base of skull into the mediastinum and because it receives contributions from all three layers of deep fascia it can become secondarily involved by infection in any other deep neck space by direct spread.

Suprahyoid Spaces

The spaces limited to above the hyoid include the submandibular space, the parapharyngeal space, the peritonsillar space, the masticator space, the temporal space and the parotid space. 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 submaxillary (perhaps better called 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 parapharyngeal space is also called the pharyngomaxillary space, the lateral pharyngeal space and the peripharyngeal space. It has been described as having the shape of an inverted cone, with the base at the base of the skull and the apex at the hyoid. The boundaries of this space are the skull base superiorly (petrous portion of temporal bone vs. sphenoid), the hyoid inferiorly, the pterygomandibular raphe anteriorly, the prevertebral fascia posteriorly, the buccopharyngeal fascia medially and the superficial layer of the deep fascia over the mandible, medial pterygoid and parotid laterally. The parapharyngeal space communicates with several other deep neck spaces, including the submandibular space, the retropharyngeal space, the parotid space and the masticator space. This has important implications in the spread of infection in the neck.

The parapharyngeal space is subdivided by the styloid process into an anterior, muscular or prestyloid compartment and a posterior, neurovascular or poststyloid compartment. The prestyloid space contains fat, muscle, lymph nodes and connective tissue and is bounded by the tonsillar fossa medially and the medial pterygoid laterally. The poststyloid space contains the carotid sheath and cranial nerves IX, X and XII. 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 peritonsillar space is formed by the capsule of the palatine tonsil medially, the superior constrictor laterally, the anterior tonsillar pillar superiorly and the posterior tonsillar pillar inferiorly. This space contains loose areolar tissue, primarily in the area adjacent to the soft palate, which explains why the majority of peritonsillar abscesses will localize to the superior pole of the tonsil.

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. 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.

The parotid space is surrounded by the superficial layer of the deep fascia that 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.

Infrahyoid Spaces

The only potential space limited to below the hyoid is the anterior visceral space. This area is enclosed by the middle layer of the deep cervical fascia and contains the thyroid gland, esophagus and trachea. This potential space runs from the thyroid cartilage into the anterior superior mediastinum to the arch of the aorta. Below the level of the thyroid gland this space communicates laterally with the retropharyngeal space (1,2,3).

DEEP NECK SPACE INFECTIONS

The incidence and morbidity of deep neck space infections has been significantly reduced with the introduction of antibiotic therapy. However, these potentially life-threatening infections continue to occur and can often present diagnostic and therapeutic dilemmas to the physician. In the following text, the presentation, origin of infection, microbiology, imaging, treatment and complications of deep neck infections will be reviewed.

Presentation/Origin of Infection

The presenting symptoms and signs of the patient with a deep neck space infection, as well as the source of infection, will vary somewhat depending upon which of the previously described spaces is involved. Retropharyngeal abscesses are the most common deep neck abscesses in the pediatric population. Nearly one-half of these abscesses affect patients between 6 and 12 months of age and 96% occur prior to 6 years of age. This is explained by the fact that the retropharyngeal space contains lymph node chains that tend to involute with age. The source of infection in children is most often a suppurative process in these nodes that drain the nose, adenoids, nasopharynx and paranasal sinuses. The more rare retropharyngeal abscess in the adult is typically caused by penetrating or blunt trauma, instrumentation such as endoscopy, intubation or NG tube placement or extension of infection from an adjoining deep neck space. The child with a retropharyngeal abscess will typically present with fever, irritability, enlarged cervical nodes and neck stiffness or torticollis. Trismus is uncommon and if the posterior pharynx can be visualized, a lateralized bulging of the posterior pharyngeal wall may be noted. A history of poor oral intake, complaint of sore throat or dysphagia and drooling may also be found. Laryngeal edema with resultant respiratory distress is not uncommon. The presentation in the adult population is slightly different in that pain, dysphagia, anorexia, snoring, nasal obstruction and regurgitation are more commonly reported.

Infection of the danger space presents in much the same manner as the retropharyngeal space. The source of infection is most often extension from the neighboring retropharyngeal, parapharyngeal or prevertebral spaces.

Historically, the most common cause of a prevertebral abscess was the extension of a tuberculous infection of a vertebral body, a Pott's abscess. The incidence of this has declined as tuberculosis has become less prevalent. Other sources of prevertebral abscess include trauma, postoperative infection, anterior spread of cervical osteomyelitis or posterior spread from the

retropharyngeal space. Complaints of these patients can be nonspecific and may include neck, back or shoulder pain that worsens with swallowing, dysphagia and rarely, dyspnea. Physical examination can be unremarkable but may include a midline bulge in the oropharynx.

It would be quite unusual to have an isolated infection of the visceral vascular space, although among intravenous drug abusers, this space may be the origin of infection. Signs of carotid sheath involvement would include pain and induration of the sternocleidomastoid, torticollis away from the affected side and spiking fevers along with evidence of sepsis.

In recent years, submandibular space abscess has become the most common of the deep neck space infections. Seventy to 85% of these cases are odontogenic in origin, the rest are caused by sialadenitis, lymphadenitis, floor of mouth lacerations or mandible fractures. The insertion of the mylohyoid along the mandible dictates which subspace is initially affected by an odontogenic infection. The apex of the first molar is above the mylohyoid, so involvement of this tooth, or teeth anterior to this, will first involve the sublingual space. In contrast, the apices of the second and third molars are below the mylohyoid and infection here will first spread to the submylohyoid space. However, as previously mentioned, these spaces freely communicate around the posterior border of the mylohyoid, and both subspaces are typically involved. These patients will present with pain in the oral cavity, drooling, dysphagia and neck stiffness but trismus is uncommon. With continued progression, the floor of mouth becomes remarkably indurated and edematous. The superficial layer of deep fascia serves as the floor of the submandibular space. It is somewhat rigid and nondistensible and limits inferior swelling. The mucosa of the floor of mouth, on the other hand, is distensible and accommodates edema but this subsequently causes superior and posterior displacement of the tongue with the potential for airway obstruction.

Ludwig's angina is the prototypical submandibular space infection, however this term should not be applied to all submandibular abscesses. In his original description in 1836, Ludwig noted the absence of concomitant pharyngeal inflammation, the "woody" induration of the neck and floor of mouth, the limitation of involvement in the neck to the submental and submandibular triangles and the lack of cervical lymphadenopathy. Some authors now recommend that the term "Ludwig's angina" be reserved for those infections that meet the following five criteria: 1. a cellulitic process of the submandibular space, not an abscess; 2. involvement of only the submandibular space, although this could be bilateral; 3. the finding of gangrene with foul serosanguinous fluid on incision, but no frank purulence; 4. involvement of the fascia, muscle and connective tissue, with sparing of the glandular tissue; and 5. direct spread of infection rather than spread by lymphatics. Patients with a true Ludwig's angina present with tender, firm swelling in the anterior neck without fluctuance, a muffled or "hot potato" voice and sialorrhea. Tachypnea, dyspnea and stridor signal impending airway compromise and warrant immediate treatment.

Parapharyngeal space abscess may follow infection in the pharynx, tonsils, adenoids, teeth, parotid or lymph node chains. Middle ear infections or mastoiditis may involve the parapharyngeal space after rupture of a Bezold's abscess on the inner aspect of the mastoid tip along the digastric ridge. Perhaps more commonly, the parapharyngeal space becomes involved from extension of infection from the nearby peritonsillar space, submandibular space,

retropharyngeal space or masticator space. Despite the multitude of potential sources, in nearly half of these cases, the etiology cannot be defined. Signs and symptoms of parapharyngeal abscess differ depending on whether the prestyloid or poststyloid compartment is involved. In addition to fever, chills and malaise, anterior infection will often cause pain, dysphagia and significant trismus due to medial pterygoid irritation. Edema in this area will cause a medial bulging of the lateral pharyngeal wall and tonsil and there will be swelling at the angle of the mandible. Posterior compartment infection does not tend to be associated with trismus or tonsillar displacement and may have no localizing signs on examination. Despite this, these patients do appear toxic and may receive the diagnosis “fever of unknown origin.” Involvement of the neurovascular structures found in this area may lead to cranial neuropathies, Horner’s syndrome, septic internal jugular thrombosis or carotid artery rupture. Any bleeding from the nose, mouth or ear in a patient with suspected deep neck abscess could be a sentinel event and should be taken very seriously.

Peritonsillar abscesses develop by direct extension of infection from a suppurative tonsillitis. These infections are uncommon in the pediatric population, but instead tend to effect post-pubescent individuals. Patients present with complaints of gradually worsening dysphagia and odynophagia, often associated with low-grade fever and malaise. They may have previously been diagnosed with pharyngitis and received antibiotic therapy, with some improvement of symptoms only to then have an abrupt recurrence of symptoms. Classic findings on examination include “hot potato” voice, trismus, bulging of the superior tonsillar pole and adjacent soft palate and deviation of the uvula to the opposite side.

Masticator and temporal space infection most often arise from infections of the third molars. Inflammation of the pterygoid muscles leads to marked trismus and pain. The posterior floor of mouth may become edematous and indurated. Externally, swelling occurs over the ramus of the mandible.

Patients with a history of chronic sialadenitis, sialolithiasis or Sjogren’s syndrome are more prone to parotid space infections. Signs of abscess formation include severe trismus, bulging of the postero-lateral pharyngeal wall and swelling over the angle of the mandible.

Anterior visceral space infections are most commonly caused by hypopharyngeal or esophageal trauma by foreign bodies or instrumentation. Much less frequently, this space may become secondarily involved by an infectious process in the thyroid. Symptoms include hoarseness, dyspnea, dysphagia or odynophagia. Examination may reveal erythema or edema of the hypopharynx, anterior neck edema, induration or crepitus. Progression of the infection may cause glottic or supraglottic edema with resultant airway compromise (1,3,4,5).

Microbiology

The vast majority of deep neck abscesses will be caused by a polymicrobial infection, and can grow as many as six different bacteria on culture. Staphylococcus aureus was the most commonly cultured organism in the preantibiotic era. Currently, aerobic Streptococcal species and non-streptococcal anaerobes are found most frequently. Other aerobes that can be involved include H. influenza, S. pneumonia, M. catarrhalis, Klebsiella, Neisseria species and Borrelia

vincentii. Commonly isolated anaerobes include Peptostreptococcus, Fusobacterium and Bacteroides. Eikenella corrodens is becoming a more frequently cultured participant in these infections, this is of clinical importance because this organism is often resistant to clindamycin. One must also remember when choosing an antibiotic, that it is not unusual for these organisms, both aerobes and anaerobes, to produce beta-lactamase. The presence of gram-negative rods in deep neck abscess is unusual although this may be seen in the elderly, debilitated, diabetic or immunocompromised patient (4,6,7).

Imaging

The diagnosis of deep neck space infection may be difficult to make based on historical and physical findings alone. Several radiographic studies are available to aid in making the diagnosis, distinguishing between cellulitis and abscess and delineating the extent of infection. The lateral neck plain film has been used in the past as a screening x-ray to look primarily at the retropharyngeal and prevertebral spaces. The quality of these x-rays is highly technique dependent--they need to be taken during inspiration with the neck in extension. The thickness of the prevertebral soft tissue can be effected not only by positioning and breathing, but also by crying and swallowing. The normal width of this soft tissue at C-2 is 7mm, at C-6 it is 14mm in children and 22mm in adults (5,8). Nagy and Backstrom, in a study of 57 pediatric patients, found that in 25% of cases, lateral x-ray was unable to definitively demonstrate the presence of deep neck infection. They demonstrated a sensitivity of 83% for lateral radiograph, compared to 100% for CT scan with contrast and concluded that despite the difference in cost, (x-ray \$39.14 vs. CT \$487.19) CT scan is the definitive study and lateral neck films do not contribute to the evaluation of patients with suspected deep neck abscess (8).

High-resolution ultrasound, although advocated by some authors, has not been widely accepted for the imaging of deep neck infection. In the hands of an experienced ultrasonographer this study can provide much useful information. It has the advantages of being portable and involving no radiation. However, even in the best of circumstances, ultrasound does not provide the kind of anatomic detail that CT with contrast is capable of producing. Ultrasound may have a role in following infection during therapy to verify improvement, or, as will be discussed later, in the use of image guided aspiration of abscesses (11).

Contrast-enhanced CT scan has become the imaging modality of choice in the evaluation of the patient with a deep neck abscess. The advantages of CT scanning are that it is a quick and easy study to obtain, it is widely available and most head and neck surgeons are very comfortable reading the images. CT is capable of providing superior anatomic detail, which delineates the extent of infection and can differentiate between cellulitis and abscess. This information is crucial for operative planning. The disadvantages of CT scan include the use of potentially allergenic injectable contrast material, the dose of ionizing radiation, the difficulty differentiating adjacent soft tissues of similar radiodensity but different composition and the production of artifact from dental amalgam (9). A study by Miller, et al compared the accuracy of diagnosing deep neck infection by physical examination (PE) versus CT scan. They found that PE was accurate in determining the presence or absence of a drainable abscess in 63% of cases, while CT scan was 77% accurate. The sensitivity and specificity for PE was 55% and 73%, compared to 95% and 53% for CT scan. They concluded that the most accurate method for

diagnosis was the combination of PE and CT, and although CT demonstrated a high false positive rate, it provided the correct diagnosis in 8/20 cases of abscess missed by PE and significantly influenced the choice of surgical approach in 25% of cases (10).

Magnetic resonance imaging (MRI) of the neck, like CT scan, can provide excellent anatomic detail. Advantages of MRI over CT include absence of ionizing radiation, a safer injectable contrast material, increased soft tissue sensitivity and contrast, multiplanar images and less artifact produced by amalgam. Disadvantages are the increased cost, increased examination time, increased dependence on patient cooperation, difficulty in performing MRI emergently and frequent distant location of the scanner, requiring transport of the patient. The utility of CT and MRI was compared in a study by Munoz, et al looking at 47 patients with neck infections. MRI was found to be better than CT in delineating anatomy, recognizing abnormality, determining extent of infection and identifying the effected spaces in the neck. Based upon these findings, they concluded that MRI may be a reasonable first choice for imaging neck abscesses (9).

Treatment

The three keys to successful management of deep neck infections are protection and control of the airway, antibiotic therapy and surgical drainage. The age-old dictum that all abscesses must be surgically drained has recently been tested in studies looking at the medical management of neck abscesses and the use of image guided aspiration of abscesses. However, many still practice by Levitt's thinking that "antibiotics are not a substitute for surgery, they should be used in conjunction with proper surgical drainage" (12).

Management of the airway in the patient with a deep neck infection is dependent upon the stability of the patient, the extent of disease and the plan of therapy. The patient who presents with dyspnea and stridor obviously necessitates immediate steps to evaluate and secure the airway. The patient who does not have signs or symptoms of airway compromise, and who does not require surgical intervention, may be closely observed, typically in an intensive care unit or monitored bed setting. For the stridorous patient or those patients going to the operating room, the airway can be secured by endotracheal intubation or tracheostomy. Oral intubation can be quite challenging if the abscess causes obstruction of the upper airway. Direct laryngoscopy, if not performed with extreme care, runs the risk of rupture of the abscess with subsequent aspiration of abscess contents and pneumonia. If the anesthesiologist has experience and is comfortable with fiberoptic intubation, this is a viable option for securing the difficult airway and avoiding a tracheostomy. If a surgical airway is necessary, it is preferable to be done in a planned and controlled manner. Although it is less than ideal, some situations may require a cricothyroidotomy or "slash" tracheostomy to secure the airway. Ideally, tracheostomy is performed with the patient awake under local anesthesia, and this is a safe and reliable method to stabilize the airway. However, the surgeon must keep in mind that tissue planes are likely to be distorted and the trachea may be deviated (6,5,11). In a review of 210 patients with deep neck abscess, Parhiscar and Har-El found that 43/210 or 20.5% of patients required tracheostomy. Seventy-five percent of patients that presented with Ludwig's angina eventually required a tracheostomy. In fact, out of 20 patients with Ludwig's angina in which endotracheal intubation was attempted, 11 failed and required "slash" tracheostomy (13).

The idea that a select group of patients with deep neck space infection can be treated with antibiotic therapy alone is gaining popularity. Obviously, those patients with CT evidence of cellulitis rather than abscess can be managed with intravenous antibiotic therapy, and the majority will improve. Most authors agree that if clinical improvement does not occur within 24 to 48 hours of medical therapy, re-imaging and possibly surgery are indicated (6,7). Currently, there are an increasing number of reports in the literature on patients with deep neck abscesses being treated successfully with medical management alone. Mayor, et al prospectively studied 31 patients with parapharyngeal, retropharyngeal or mixed deep neck infections. Based on CT findings, 19 patients were diagnosed with abscessed, while 12 patients had cellulitis. The majority of patients were treated with the combination of cefotaxime and metronidazole, several received clindamycin and a few were given amoxicillin/clavulanic acid. All patients received methylprednisolone and intravenous fluid hydration. They found that 90% of their patients responded to this regimen and only 3 patients required surgical drainage, although another 4 patients had their parapharyngeal abscesses rupture spontaneously. The average length of hospital stay for their patients was 8 days, which compares favorably with other series looking at length of stay after surgery (14). Nagy et al, evaluated similar points in a review of 47 pediatric patients. In this study, 51% of patients responded to medical therapy alone, however only 7/24 had CT evidence of abscess, the remainder had cellulitis. The antibiotics used in this study were either intravenous clindamycin, ceftriaxone, ampicillin/sulbactam or a combination. In the group treated with antibiotics, they found an average length of stay of 4.8 days, compared to 3.6 days for patients that had incision and drainage (15).

The decision on which antibiotic therapy to empirically start for patients with deep neck space infections should be directed by the fact that the most commonly isolated organisms are Streptococcal species and anaerobes. The majority of infections are polymicrobial so broad antibiotic coverage is desirable. The percentage of beta-lactamase producing bacteria varies in different reports, 17 to 46%, but most authors consider it reasonable to begin therapy with a beta-lactamase resistant penicillin, likely in combination with metronidazole to improve anaerobe coverage. Third generation cephalosporins are an alternative, as is clindamycin for the penicillin allergic patient. One caveat would be to be careful when using clindamycin alone because of the resistance of *Eikenella* species to this antibiotic. Improved gram-negative coverage should be considered in debilitated patients or immunocompromised patients. Of course, antibiotic therapy should always be adjusted as directed by culture and sensitivity findings in those cases in which a specimen is obtained (11).

For those patients requiring surgical drainage, the approach will be dictated by the location of the abscess and its relationship to other structures in the neck. First, one must decide if intraoral incision is an option, or if external drainage is required. In the past, the use of transoral incision and drainage was essentially limited to isolated retropharyngeal abscesses. It was thought that the use of this approach to the parapharyngeal space placed the neurovascular structures of the poststyloid compartment at undue risk. However, with the reliable imaging produced by contrast-enhanced CT scanning, we are now capable of identifying the location of the great vessels in relation to the abscess cavity. Using preoperative imaging, Nagy, et al found that 22/23 children were successfully treated by transoral drainage of their retropharyngeal, parapharyngeal or combined abscess. Only one patient failed this treatment and required a second operation with external drainage. The medial border of the parapharyngeal space is the

buccopharyngeal fascia around the superior pharyngeal constrictor. Transoral drainage involves a cruciate incision through the mucosa followed by blunt dissection through the constrictor muscle (15). This approach is probably only safe if the great vessels can be definitively identified on preoperative CT and confirmed to be lateral to the abscess cavity. Cases in which the vessels are located medial to or within the abscess should not be approached in this manner since if bleeding were to be encountered, getting proximal and distal control of the vessels would be difficult.

External drainage of deep neck abscesses can be accomplished in several ways. When it comes to these procedures, the priorities of the patient and surgeon are likely to be different. The patient is worried about where the incision will be and the cosmetic outcome. The surgeon is worried about adequate exposure to eradicate the infection while avoiding damage to vital structures. Therefore, the importance of preoperative counseling and informed consent cannot be over emphasized. Again, the approach will be primarily dictated by the location of the abscess and what spaces in the neck are involved. Levitt describes using either an anterior or a posterior approach to the retropharyngeal, danger, prevertebral and visceral vascular spaces. The anterior approach involves an incision paralleling the anterior border of the sternocleidomastoid, dissection along the anterior border of the muscle, lateral retraction of the carotid sheath, medial retraction of the larynx, trachea and thyroid and exposure of the abscess cavity at the hypopharynx. The posterior approach utilizes an incision behind the sternocleidomastoid, medial and anterior retraction of the muscle and carotid sheath, opening into the abscess from posterior to the great vessels. This approach potentially places at risk the sympathetic chain and phrenic nerve. The submandibular space can be drained via a transverse incision paralleling and 2 cm below the mandible, similar to that used for a submandibular gland excision. In this case, the posterior belly of the digastric is identified under the gland, which is then retracted laterally. The mylohyoid muscle is then bluntly divided perpendicular to its fibers, thereby opening into this space. More limited infections here can be approached with a transverse submental incision and blunt spreading of the mylohyoid. The parapharyngeal space can be approached using an incision along the anterior sternocleidomastoid, the above described submandibular incision or a T-shape incision that combines the two. Dissection proceeds along the anterior aspect of the muscle until the digastric sling is encountered. This is followed anteriorly and the muscle and overlying submaxillary gland are elevated. Blunt finger dissection can then be used in this space from the styloid process and skull base, inferiorly along the carotid sheath (12).

An alternative to open drainage of neck abscesses is the use of image guided aspiration or catheter insertion. The successful use of these methods probably is most dependent upon proper patient selection. Those patients with smaller, more isolated and uniloculated abscesses are more likely to respond favorably to this treatment. The use of image guidance, whether CT or ultrasound, to perform aspiration helps to ensure that the needle or catheter is being placed appropriately in the affected space while vital structures are avoided. Also, reexamination after aspiration can determine if the evacuation is complete. Poe, et al described a small series of patients that were successfully treated with percutaneous CT guided aspiration of deep neck abscess along with antibiotic therapy. They propose that CT guided aspiration has the benefits of early collection of a specimen to identify the infecting organisms, significantly reduced expense compared to a trip to the operating room and the avoidance of a scar on the neck (16). Ultrasound guidance was used for needle aspiration or pigtail catheter insertion in a study by

Yeow, et al. This was a prospective study of 15 patients with uniloculated deep neck abscesses. Ten patients had needle aspiration, six needed only one aspiration, two needed two aspirations and two eventually required open surgical drainage. All five patients treated with pigtail catheter placement responded well and avoided surgery (17). Both authors admit that while no complications were encountered in their series, the potential for damage to neurovascular structures does exist and must be discussed with the patients. Also, the successful performance of these procedures is highly dependent upon the skill and experience of the interventional radiologist.

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 asphyxia 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. Rupture of the abscess, either spontaneously or with manipulation such as intubation, with associated aspiration can result in severe pneumonia, lung abscess or empyema.

Vascular complications of deep neck infections can include jugular vein thrombosis or carotid artery rupture. Lemierre's syndrome is jugular vein thrombosis that occurs specifically in association with an oropharyngeal infection, however, any infection of the parapharyngeal or visceral vascular spaces can cause this complication. Jugular vein thrombosis presents with fevers, chills and prostration as well as swelling and pain along the sternocleidomastoid. It can lead to bacteremia or septic embolization with resultant distant infection. Pulmonary embolism occurs in up to 5% of these patients. Patients that develop deep neck infection secondary to intravenous drug abuse are particularly prone to have this complication. The most common organism causing Lemierre's syndrome is *Fusobacterium necrophorum*, while in IV drug abusers *Staphylococcus* is most common. Imaging with either ultrasound, CT or MRI may assist in making the diagnosis. Treatment involves intravenous antibiotic therapy, preferably directed by blood culture results. The use of anticoagulation is controversial but may speed recovery and prevent pulmonary embolism. If medical therapy fails, then ligation and excision of the infected vessel is indicated.

Carotid artery rupture, although rare, carries a mortality rate between 20% and 40%. This can occur when infection involving the carotid sheath leads to arterial wall weakening, erosion and eventual hemorrhage. Salinger and Pearlman, in a review of 227 cases of deep neck abscess complicated by hemorrhage, found that 62% of ruptures occur from the internal carotid artery, 25% involve the external carotid and 13% involve the common carotid. In their series, of the 73 patients who were treated with artery ligation, 64% survived. Artery rupture may be heralded by recurrent small bleeds from the ear, nose or mouth, the onset of shock, a protracted clinical course, hematoma in the nearby tissue, Horner's syndrome or unexplained cranial neuropathies. Treatment necessitates obtaining proximal and distal control, followed by ligation of the vessel. Repair of the artery by patching or grafting is restricted by the infected environment.

Extension of infection from the anterior visceral, retropharyngeal, visceral vascular, danger or prevertebral spaces can lead to mediastinitis. Patients will complain of increasing difficulty breathing and chest pain. Chest x-ray may show a widened mediastinum or pneumomediastinum. A CT scan of the chest can help to delineate the extent of involvement. Treatment involves aggressive antibiotic therapy and immediate surgical drainage. Disease limited above the tracheal bifurcation can often be managed through a transcervical approach. More extensive disease will likely require chest tube placement or thoracotomy (3,4,6,7,11)

Special Consideration

The treatment of deep neck space infections with antibiotic therapy and drainage via aspiration or surgery is most often definitive and recurrence of these cases is rare. The exception to this rule is the deep neck infection that occurs in association with a preexisting congenital abnormality. So that, in the patient that presents with a prior history of a similar deep neck infection or abscess, the level of suspicion should be raised for an underlying lesion. Imaging, particularly CT scan, can be extremely helpful in making the diagnosis in these cases. In a review of 12 cases of recurrent deep neck infection, Nusbaum, et al, found the most common underlying congenital anomaly to be a second branchial cleft cyst. Other causes included first, third and fourth branchial cleft cysts, lymphangiomas, thyroglossal duct cysts and a cervical thymic cyst (18).

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