Anaerobic Bacteria in Upper Respiratory Tract and Head and Neck Infections in Children: Microbiology and Management

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Summary

Anaerobes are the predominant components of oropharyngeal mucous membranes bacterial flora, and are therefore a common cause of bacterial infections of endogenous origin of upper respiratory tract and head and neck in children. This chapter summarizes the aerobic and anaerobic microbiology and antimicrobials therapy of acute and chronic upper respiratory tract and other head and neck infections.These infections include acute and chronic otitis media, mastoiditis and sinusitis, pharyngo-tonsillitis, peritonsillar, retropharyngeal and parapharyngeal abscesses, suppurative thyroiditis, cervical lymphadenitis, parotitis, siliadenitis, and deep neck infections including Lemierre Syndrome. The recovery from these infections depends on prompt and proper medical and when indicated also surgical management.

Introduction

The management of upper respiratory tract infections (URTI) and head and neck infections in children requires an accurate clinical and bacteriological diagnosis, followed by an initial empiric antimicrobial therapy that may be adjusted once the identification of the causative organism(s) is available. The increasing antimicrobial resistance of many bacterial pathogens has made the treatment of these infections more challenging.[1,2]

This review summarizes the aerobic and anaerobic microbiology and antimicrobials therapy of acute and chronic URTI and other head and neck infections in children.

Predominant aerobic and anaerobic bacteria

Streptococcus pneumoniae, Haemophilus influenzae and Moraxella catarrhalis are the predominate aerobic pathogens recovered in acute URTI. (**Table 1)** Their resistance to antimicrobials has significantly increases in the last 30 years. Endogenous oropharyngeal anaerobes are commonly recovered in chronic URTI and head and neck infections, some of which can be life-threatening (**Tables 1 and 2**).[3] Because anaerobes are difficult to isolate, they are often overlooked. Furthermore, their exact role is difficult to ascertain from many of the past studies because of the inconsistent methodologies used for their isolation and identification in many studies. Their isolation and identification requires appropriate methods of collection, transportation and cultivation of specimens.[4-6] Treatment of anaerobic infection is complicated by their polymicrobial nature, and the growing antimicrobials resistance and slow growth of these bacteria.

An important mechanism of resistance of both aerobic (*Staphylococcus aureus, H. influenzae and M. catarrhalis*.) and anaerobic Gram-negative bacilli (AGNB, pigmented *Prevotella* and *Porphyromonas* spp.) production of the

enzyme beta-lactamase. Beta-lactamase-producing bacteria (BLPB) can not only protect themselves from beta-lactam antibiotics but can also shield other penicillin-susceptible organisms from the activity of these agents [7].

Specific infections (Table 1)

Table 1: Aerobic and anaerobic bacteria isolated in upper respiratory tract and head and neck infections

Type of Infection	Aerobic and Facultative Organisms	Anaerobic Organism
Otitis media: acute	*S. pneumoniae*	*Peptostreptococcus* spp.
	*H. influenzae**	
	*M. catarrhalis**	
Otitis media: chronic, and	*S. aureus**	Pigmented *Prevotella* and
Mastoiditis	*Escherichia coli**	*Porphyromonas* spp.
	*Klebsiella pneumoniae**	*Bacteroides* spp.*
	*Pseudomonas aeruginosa**	*Fusobacterium* spp.*
	Peptostreptococcus spp.	
Peritonsillar and retropharyngeal	*S. pyogenes*	*Fusobacterium* spp.*
abscess	*S. aureus**	*Pigmented Prevotella* and
	S/. pneumoniae	*Porphyromonas* spp.*
Recurrent tonsillitis	*S. pyogenes*	*Fusobacterium* spp.*
	*H. influenzae**	
	*S. aureus**	
Suppurative thyroiditis	*S. pyogenes*	*Pigmented Prevotella* and
	*S. aureus**	*Porphyromonas* spp.*
Sinusitis: acute	*H. influenzae**	*Peptostreptococcus* spp.
	S. pneumoniae	
	*M. catarrhalis**	
Sinusitis: chronic	*S. aureus**	*Fusobacterium* spp *
	S. pneumoniae	*Pigmented Prevotella* and
	H. influenzae	*Porphyromonas* spp.*
Cervical lymphadenitis	*S. aureus**	*Pigmeted Prevotella* and
	Mycobacterium spp.	*Porphyromonas* spp.*
		Peptostreptococcus spp.
Postoperative infection	*Staphyloccus* spp.*	*Fusobacterium* spp.*
disrupting oral mucosa	*Enterobacgeriaceae**	*Bacteroides* spp.*
	Staphylococcus spp.*	*Pigmented Prevotella* and
		Porphyromonas spp.*
		Peptostreptococcus spp.
Deep neck species	*Streptococcus spp.*	*Bacteroides* spp.*
	*Staphylococcus spp.**	*Fusobacterium* spp.*
		Peptostreptococcus spp.*
Odontogenic complications	*Streptococcus* spp.	*Pigmented Prevotella* and
	Staphylococcus spp.*	*Porphyromonas* spp.*
		Peptostreptococcus spp.
Oropharyngeal: Vincent's angina	*Streptococcus* spp.	*Fusobacterium necrophorum**
Necrotizing ulcerative gingivitis	*Staphylococcus* spp.*	*Spirochetes, P. intermidia Fusobacterium* spp

*Organisms that have the potential of producing beta-lactamase.

Table 2: Anaerobic bacteria most frequently encountered in URTI and head and neck infections.

Organism	Infectious site
GRAM-POSITIVE COCCI	
Peptostreptococcus spp.	Respiratory tract, deep neck and soft tissue infections
Microaerophilic streptococci*	Sinusitis, brain abscesses
GRAM-POSITIVE BACILLI	
Non-spore-forming	
Actinomyces spp.	Intracranial abscesses, chronic mastoiditis, head and neck infections
Propionibacterium acnes	infections associated with foreign body
Bifidobacterium spp.	Chronic otitis media, cervical lymphadenitis
SPORE-FORMING	
Clostridium sp.	
C. perfringens	Soft tissue infection
C. difficile	Colitis, antibiotic-associated diarrheal disease
C. ramosum	Soft tissue infections
GRAM-NEGATIVE BACILLI	
B. fragilis group	Chronic otitis and sinusitis (rare)
Pigmented *Prevotella* and *Porphyromonas*	Orofacial and deep neck infections, periodontitis
P. oralis	Orofacial infections
P. oris-buccae	Orofacial infections
Fusobacterium spp.	
F. nucleatum	Orofacial, deep neck, and respiratory tract infections, brain abscesses, bacteremia
F. necrophorum	Bacteremia
*Not obligate anaerobes.	

Otitis media

Acute Otitis Media (AOM): *S. pneumoniae, H. influenzae* and *M. catarrhalis* are the principal etiologic agents in bacterial AOM accounting for about 80% of the bacterial isolates.[8] Less frequent cause of AOM include group A beta-hemolytic streptococci (GABHS), *S. aureus*, *Turicella otitidis, Allioicoccus otitis, Chlamydia* spp., *Staphylococcus epidemidis* and various aerobic Gram-

negative bacilli,[10] (e.g. *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Proteus* spp.).Viruses were recovered in the middle ear fluid of 14.3% of children. [11]

Anaerobes were isolated from 5-15% of acutely infected ears[12] and 42% of culture-positive aspirates of serous otitis media[13]. *Peptostreptococcus* spp. and *Propionibacterium acnes* predominant in acute and serous otitis and anaerobic Gram positive bacilli (AGNB) were also recovered in serous otitis media. Persistent otitis media can become a chronic.

The anaerobes recovered in AOM are susceptible to beta-lactam antibiotics used to treat AOM. However, TMP/SMX is effective against only 50% of *Peptostreptococcus* spp., the major anaerobe isolated in AOM.

Chronic otitis media (COM) and cholesteatoma: The most common isolated aerobes are *Pseudomonas aeruginosa* and *S. aureus* (including Methicillin Resistant *S. aureus* - MRSA). Anaerobes were isolated from about 50% of the patients with chronic suppurative otitis media [3,4,14,15] and those with infected cholesteatoma [16-17]. The predominant anaerobes were AGNB and *Peptostreptococcus* spp. Anaerobes were often recovered mixed with aerobic bacteria, and the number of isolates/specimen ranged between 2 and 6. Many of these organisms can produce beta-lactamase that might have contributed to the high failure rate of beta-lactam antimicrobials.

The microbiology of infected cholesteatomas is similar to the one of COM evolving *P. aeruginosa*, *S. aureus,* AGNB, *Fusobacterium* and *Peptostreptococcus* spp. [16-17]. Since cholesteatoma associated with COM media harbors organisms similar to those isolated from chronically infected ears, the cholesteatoma may serve as a nidus of the chronic infection.

Treatment include clindamycin, cefoxitin, a combination of metronidazole plus either a macrolide, or amoxicillin, a penicillin (i.e. amoxicillin, ticarcillin) plus a beta-lactamase inhibitor (i.e. clavulanic acid, sulbactam). When *P. aeruginosa* is a true pathogen, parenteral therapy with aminoglycosides, cefepime or ceftazidime or a fluoroquinoline (only in postpubertal patients) should be added. Parenteral therapy with a carbapenem provides adequate coverage for all potential pathogens, anaerobic as well as aerobic bacteria.

Mastoiditis

Acute mastoiditis: *S. pneumoniae,* GABHS, *S. aureus, H. influenzae* are the common organisms recovered. [18] Rare isolates include *P. aeruginosa* and other aerobic gram-negative bacilli, anaerobes, and *Mycobacterium tuberculosis*.

Treatment is guided by cultures and includes parenteral antimicrobials and myrinyotomy with tympanostomy tube. Cefuroxime, ceftriaxone, or the combination of a penicillin plus a beta-lactamase inhibitor (i.e. ticarcillin plus clavulanate) are appropriate.

Proper therapy generally leads to improvement within 48 hours. However, toxicity increases or the disease progresses or does not improve within 48 hours, surgical intervention and drainage may be necessary.

Chronic mastoiditis: Most infections are polymicrobial and the predominant anaerobes are AGNB (including *pigmented Prevotella* and *Porphyromonas* and *B.*

fragilis group), Gram-positive cocci (*Peptostreptococcus* spp., and microaerophilic streptococci), *Actinomyces* spp., *F. nucleatum*, *P. acnes,* and *Clostridium* spp. The main aerobes are *S. aureus*, *P. aeruginosa*, *Enterobacteriaceae,*, and *K. pneumoniae*. *S. pneumoniae* and *H. influenzae* are infrequently recovered. [19]

Antimicrobial therapy should be directed at the eradication of both aerobic and anaerobic bacteria. *B. fragilis,* and many pigmented *Prevotella* and *Porphyromonas* and *Fusobacterium* spp. are resistant to beta-lactam antibiotics.

Clindamycin, metronidazole, chloramphenicol, cefoxitin, or the combination of a penicillin and a beta lactamase-inhibitor cover anaerobic bacteria. Therapy should also include antimicrobials effective against *S. aureus* including Methicillin Resistant *Staphylococcus aureus* (MRSA), including oxacillin, vancomycin, or linezolid and Gram-negative aerobic bacilli including *P. aeruginosa* (an aminoglycoside, ceftazidime, cefipime, or a fluroquinolone). The carbapenems (i.e. imipenem, meropenem) provide therapy of most potential pathogens. Surgical drainage is indicated in many cases.

Sinusitis

Acute sinusitis: The bacteria recovered from children with community-acquired acute purulent sinusitis are the common respiratory pathogens (*S. pneumoniae, H. influenzae, M. catarrhalis,* and GABHS) and *S. aureus*. [20,21] *S. aureus* is a common pathogen in sphenoid sinusitis.[22] The infection is polymicrobial in about a third of the cases.

When appropriate methods for their recovery are employed anaerobes account for about 8% of isolates and are often recovered from in association with an odontogenic infection, mostly of the roots of the premolar or molar teeth). [23,24]

P. aeruginosa and other aerobic and facultative Gram-negative rods are common in nosocomial sinusitis (especially in patients who have nasal tubes or catheters), the immunocompromised, patients with human immunodeficiency virus (HIV) infection and cystic fibrosis.[25] However, anaerobic bacteria can also be isolated in these patients.

The choice of antimicrobial therapy is similar to the one of AOM and are given for 10 to 14 days.[20] Patient who fails to show significant improvement within 48 hours or shows signs of deterioration, sinus punction (surgical drainage) may be needed, and sinus irrigation and culture of the aspirate is carried out.

Chronic sinusitis: Although the etiology of the inflammation associated with chronic sinusitis is uncertain, bacteria can be isolated in the sinus cavity in these patients. Bacteria are believed to play a major role in the etiology and pathogenesis of most cases of chronic sinusitis, and antimicrobials are often prescribed for the treatment of this infection.

The usual pathogens in acute sinusitis (eg, *S. pneumoniae*, *H. influenzae*, *M catarrhalis*) are found with lower frequency [26-29]. *S. aureus* (including MRSA), can also be recovered. Gram negative enteric rods were also reported especially in nosocomial sinusitis and sinusitis in intubated patients. [30] These included *P. aeruginosa, Klebsiella pneumoniae, Proteus mirabilis, Enterobacter* spp. and *E. coli*. Polymicrobial infection is common in chronic sinusitis, which is synergistic and may be more difficult to eradicate with narrow-spectrum antimicrobial agents.

Numerous studies have examined the bacterial pathogens associated with chronic sinusitis. However, most did not employ methods that are adequate for the recovery of anaerobic bacteria. Anaerobes were recovered from over half of the patients in studies where methods adequate for their recovery were utilized. [26,31]

Anaerobic organisms are isolated from up to 67% of children [32-33] and adults[26] with chronic maxillary[25], ethmoid[27], and frontal[28] sinusitis and acute exacerbation of chronic sinusitis [29]. An average of three anaerobes and two aerobes per sinus were recovered in patients with these infections[26-29]. Anaerobes predominate in chronic maxillary sinusitis associated with odontogenic infection [30-31]. Persistent sinusitis that fails to respond to antimicrobials can become chronic with emergence of resistant anaerobic and aerobic bacteria. The gradual appearance of such bacterial flora was demonstrated in a series of five patients who had repeated endoscopic aspirations of the maxillary sinus over a period of 34-50 days. [34]

Chronic sinusitis caused by anaerobes is a particular concern because many of the complications (eg, mucocele formation, osteomyelitis, intra cranial abscess) are associated with recovery of these organisms. [3,4]

Antimicrobials used for chronic sinusitis therapy should be effective against aerobic and anaerobic BLPB; These include clindamycin, the combination of metronidazole and a penicillin or a macrolide, or the combination of penicillin and a beta-lactamase inhibitor, or the 'newer' quinolones (adults only with antianaerobic coverage (e.g. moxifloxacin). All of these agents (or similar ones) are available in oral and parenteral forms.

Other effective agents are available only in parenteral form (e.g. cefoxitin, carbapenems). If Gram-negative organisms, such as *P. aeruginosa*, may be involved, parenteral therapy with aminoglycosides, a fourth-generation cephalosporin (cefepime or ceftazidime) or oral or parenteral treatment with a fluoroquinolone (only in postpubertal patients) is added. *S. aureus* (including MRSA) treatment may be required.

The length of therapy is at least 21 days, and may be extended up to 3 month. Fungal sinusitis can be treated with surgical debridement and antifungals.

In contrast to acute sinusitis that is generally treated vigorously with antibiotics many physicians believe that surgical drainage and not antibiotics is the mainstay of therapy in chronic sinusitis.

Pharyngo-tonsillitis (PT)

The pathogens implicated in PT are Groups A, B, C and G streptococci, *Neisseria gonorrhoeae, Neisseria meningitides, Corynebacerium diphtheriae, Corynebacterium hemolyticum, and Arcanobacterium hemolyticum.* Indirect evidence supports the involvement of anaerobes in acute and chronic tonsillitis[35]. The anaerobes associated with PT are *Fusobacterium* spp., AGNB, and *Peptostreptococcus* spp.

The pathogenic role of anaerobes in the acute and chronic inflammatory process of the tonsils is supported by several clinical and laboratory findings: their major role in complications of tonsillitis such as thrombophlebitis of the internal jugular veins, which often causes postanginal sepsis [3-4], their isolation from 25% of suppurative cervical lymph nodes associated with the presence of dental or

tonsillar infections [36], their recovery in a polymicrobial infection from tonsillar, peritonsillar or retropharyngeal abscesses in many cases without any aerobic bacteria [37], the isolation of anaerobes from tonsils in Vincent's angina [3-4], the recovery of encapsulated pigmented *Prevotella* and *Porphyromonas* spp. in acutely inflamed tonsils, the isolation of anaerobes from the core of recurrently inflamed non- GABHS tonsils [38], and the response to antimicrobials in patients with non-GABHS tonsillitis [39-41]. Furthermore, immune response against *P. intermedia* can be detected in patients with non-GABHS tonsillitis [42]; and an immune response can also be detected against *P. intermedia* and *F. nucleatum* in patients who recovered from peritonsillar cellulitis or abscesses [43] and infectious mononucleosis [44].

The growing inability of penicillin to eradicate GABHS is an important clinical problem. Recent studies showed that penicillin failed to eradicate GABHS in acute-onset pharyngitis in 35% of patients treated with oral penicillin V and 37% who received intramuscular penicillin [45].

Various theories have been offered to explain this penicillin failure that may lead to recurrent PT [46]. Some postulate that bacterial interactions between GABHS and members of the pharyngo-tonsillar bacterial flora explain these failures. These explanations include the "shielding" of GABHS from penicillins by aerobic (e.g. *S. aureus, H. influenzae*) and anaerobic (AGNB) BLPB that colonize the pharynx and tonsils [6,46], the absence of normal flora organisms that interfere with the growth of GABHS [47]. Internalization of GABHS (survives within epithelial cells, escaping eradication by penicillins and the co-aggregation between *M. catarrhalis* and GABHS [48].

Even though antibiotics other than penicillin are more effective in the bacteriological and clinical cure of GABHS PT, penicillin is still recommended in some guidelines as the antibiotics of choice. The antibiotics found to be more effective included cephalosporins, lincomycin, clindamycin, macrolides, and amoxicillin-clavulanate [7, 26, 46]. Some of these agents were more effective than penicillin in acute (cephalosporins, macrolides) and others (lincomycin, clindamycin, and amoxicillin-clavulanate) in recurrent GABHS PT.

Penicillin failure in treatment of recurrent and chronic tonsillitis is even higher than the failure of therapy of acute infection. Several clinical studies demonstrated the superiority of lincomycin, clindamycin, and amoxicillin-clavulanic acid or a macrolide (e.g., erythromycin) plus metronidazole, over penicillin. These antimicrobial agents are effective against aerobic as well as anaerobic BLPB and GABHS in eradicating recurrent tonsillar infection. Referral of a patient for tonsillectomy because of recurrent GABHS PT should be considered only after these medical therapeutic modalities have failed.

Peritonsillar, retropharyngeal, parapharyngeal and deep neck abscesses

The microbiology of these abscesses is similar because the causing bacteria reflect the host's oropharyngeal flora. Predominant anaerobes isolated are *Prevotella, Porphyromonas, Fusobacterium* and *Peptostreptococcus* spp.; aerobic organisms are GABHS, *S. aureus* (including MRSA) and *H. influenzae*. Anaerobes are isolated from most abscesses whenever appropriate techniques for their cultivation have been employed while GABHS is found in only about

one-third of cases.[37,49] Elevated antibody levels to *F. nucleatum* and *Prevotella intermedia*, known oral pathogens was found in children who had peritonsillar abscess or cellulitis, supporting their pathogenic role.[43]

More than two-thirds of deep neck abscesses contain BLPB.[37,49] Retropharyngeal cellulitis and abscess in young children are more likely to have pathogenic aerobic isolates (*Streptococcus* spp., *S. aureus*), alone or mixed.[50] *Fusobacterium necrophorum* is especially associated with deep neck infections that cause septic thrombophlebitis of great vessels and metastatic abscesses (Lemierre disease).[51] Rarely, *M. tuberculosis*, atypical mycobacteria or *Coccidioides immitis* is recovered.

Surgical drainage of an abscess is the therapy of choice. However, administration of antimicrobials is also required. Because of their similar microbiology, the antimicrobial management of these abscesses is simmilar. Early initiation of antimicrobials at the stage of cellulites can abort abscess formation. When an abscess is diagnosed the abscess needs drainage. Because of the risk of recurrence, tonsillectomy is performed 6-8 weeks later. However, this is not always needed in children where recurrence rate is 7%, compared to 16% in adults. Controversy exists regarding management of peritonsillar abscess on an outpatient basis, after needle aspiration of the abscess. [52]

The isolation of aerobic and anaerobic BLPB from most abscesses mandates the use of antimicrobials effective against these organisms. Efficacy antimicrobials include cefoxitin, a carbapenem (i.e., imipenem, meropenem), the combination of a penicillin and a beta-lactamase inhibitor, or clindamycin. MRSA coverage may be needed.

Parotitis and sialadenitis

The parotid gland is the salivary gland most commonly affected by inflammation. The most common pathogens associated with acute bacterial parotitis and sialadenitis are *S. aureus* and anaerobic bacteria. The predominant anaerobes include AGNB, *Fusobacterium* spp., and *Peptostreptococcus* spp. *Streptococcus* spp. (including *S. pneumoniae*) and gram-negative bacilli (including *E. coli*) have also been reported [53-54]. Gram-negative organisms are often seen in hospitalized patients. Organisms less frequently found are Arachnia, *H. influenzae, K. pneumoniae, Salmonella* spp., *P. aeruginosa, Treponema pallidum,* cat-scratch bacillus, and *Eikenella corrodens*. *Mycobacterium tuberculosis* and atypical mycobacteria are rare causes of parotitis.

Therapy includes maintenance of hydration and administration of parenteral antimicrobial therapy. Once an abscess has formed, surgical drainage is required. The choice of antimicrobials depends on the etiologic agent. Antimicrobials should be directed to the eradication of the predominant organisms causing these infections. To assure that therapy is individualized, appropriate specimens should be collected from the infected site and processed for aerobic and anaerobic bacteria. Most patients respond adequately to proper antimicrobial therapy; however, once an abscess has formed surgical drainage is requires.

Broad antimicrobial therapy is indicated to cover all possible aerobic and anaerobic pathogens, including adequate coverage for *S. aureus*, hemolytic

streptococci, and beta-lactamase producing AGNB. Many of the AGNB causing these infections are BLPB. [49]

Clindamycin, cefoxitin, chloramphenicol, imipenem, meropenem, the combination of a penicillin plus beta-lactamase inhibitor or metronidazole plus a macrolide, will provide adequate coverage for anaerobic as well as aerobic bacteria. A penicillinase-resistant penicillin (i.e. nafcillin) or first-generation cephalosporin is generally adequate when the infection occurs is caused only by staphyloccoci. However, the presence of MRSA may mandate the use of vancomycin or linezolid.

Cervical lymphadenitis (CL)

Viruses are the commonest etiology of bilateral CL in children. [55] The predominate viruses are Epstein-Barr, cytomegalovirus, *Herpes simplex*, adeno virus, enterovirus, roseola, rubella and HIV. Other pathogens include *Mycoplasma pneumoniae* and *C. diphtheriae*. The most frequent bacterial organisms causing acute unilateral infection associated with facial trauma or impetigo are *S. aureus* and GABHS.[55] Other causes include *Bartonella henselae, H. influenzae, Francisella tularensis, Pasteurella multocida, Yersinia pestis, Yersinia entercolitica, Listeria monocytogenes, A. actinomycetemcomitans, Burkholderia gladioli, Spirillum minor, Nocardia brasiliensis, M. tuberculosis,* and non-TB *mycobacterium* [56] Other rare aerobic pathogens are *S. pneumoniae* and Gram-negative rods. Adenitis in newborns is often associated with group B streptococci. The most common fungi involved are *Histoplasma capsulatum, Coccidioides immitis,* and *Paracoccidioides* spp.

Studies that utilized methodologies that were adequate for the recovery of anaerobes demonstrated their importance in CL mostly in association with dental or periodontal disease. [36,57] The predominate anaerobes are AGNB, *Fusobacterium* spp., and *Peptostreptococcus* spp.

Most patients do not require specific therapy as they result from viral pharyngitis or stomatitis. Empiric antimicrobial therapy for bacterial infection should cover *S. aureus* (including MRSA) and GABHS. Oral antimicrobials should include penicillinase-resistant penicillins such as cloxacillin, dicloxacillin, or the combination of a penicillin and a beta-lactamase inhibitor.

Parenteral therapy may be needed in toxic patients. Those allergic to penicillin can be treated with a macrolide or clindamycin. Treatment should be administered for at least 14 days. Therapy against anaerobic and aerobic BLPB includes clindamycin, the combination of a penicillin and a beta-lactamase inhibitor, or the combination of a penicillin or macrolide with metronidazole. If no improvement occurs after 36 to 48 hours of therapy a reassessment is required.

Early institution of antibiotics prevents most cases of pyogenic adenitis from progressing to suppuration. However, once fluctuation occurs, the abscess should be drained.

Suppurative thyroiditis (ST)

S. aureus, GABHS, *S. epidermidis,* and *S. pneumoniae,* are the predominant aerobic isolates. The most common anaerobes are AGNB, *Peptostreptococcus* spp. and *Actinomyces* spp.[58,59] Agents that are rarely recovered include *Klebsiella* spp.,

H. influenzae, Streptococcus viridans, Salmonella spp., *Enterobacteriaceae, M. tuberculosis*, atypical mycobacteria, *Aspergillus* spp., *C. immitis*, *Candida* spp., *Treponema pallidum*, and *Echinococcus* spp. Viruses associated with subacute thyroiditis are measles, mumps, influenza, enterovirus Epstein-barr, adenovirus, echovirus, and St. Louis encephalitis.

A broad coverage of antimicrobials is indicated, at least until culture results are available. Empiric therapy should cover *S. aureus* (including MRSA) and GABHS. Oral antimicrobials should include penicillinase-resistant penicillins (ie.. dicloxacillin) or amocillin-clavulanate. Patients allergic to penicillin can be treated with a macrolide or clindamycin. Parenteral therapy may be required in toxic patients (see previous section). Treatment should be administered for at least 14 days.

Early institution of treatment with antibiotics can prevent most cases of ST from progressing to suppuration. However, once fluctuation occurs, antibiotic therapy alone is generally not sufficient.

Surgical drainage is indicated when antibiotic therapy fails to control the infection. If extensive necrosis or persistence of infection in spite of antibiotics is demonstrated, lobectomy may be required.[59]

Deep neck infections

These infections generally follow oral, dental, and pharyngeal infections and are generally polymicrobial, involving the aerobic and anaerobic bacteria that caused the primary infections. They occur in the deep posterior neck (retropharyngeal, prevertebral, and visceral vascular), suprahyoid (pharygomaxillary, submandibullar, mandibular, masticator, temporal, parotid, and peritonsillar) and infrahyoid spaces.

The predominant organisms recovered from deep facial infections are *S. aureus* (including MRSA), GABHS and anaerobic bacteria of oral origin. These include pigmented *Prevotella* and *Porphyromonas* as well as *Fusobacterium* spp..[3]

The classic *Ludwig's angina* involves a bilateral infection of both the submandibular and sublingual spaces [3]. A variety of microorganisms has been recoverd from cases of Ludwig's angina. However, anaerobic bacteria predominate. These include *Fusobacterium* spp., AGNB, and *Peptostreptococcus* spp. Often, one or more of the following also have been found: staphylococci, streptococci, *S. pneumoniae*, *E. coli,* Spirochetes, *H. influenzae,* and *Candida albicans.*

Cysts (thyroglossal duct, cystic hygromas, branchial cleft, laryngoceles, and dermoid cysts) can become inflamed and secondarily infected. The organisms causing these infections can originate from either the skin or the oropharynx and include oral anaerobes. Treatment of these infection includes surgical drainage, and antimicrobial therapy. [60] Antimicrobial selection is similar to one outlined for deep neck abscesses.

Lemierre syndrome

This syndrome is a rare but severe life-threatening complication of oral infections, particularly those resulting in lateral pharyngeal space infection. It

is characterized as thrombosis and suppurative thrombophlebitis of the internal jugular vein that is associated with spread of septic emboli to the lungs and other sites. Before the availability of antimicrobial agents, death was the common result, unless patients were treated with surgical ligation of the vein.[51,,61]

Fusobacterium is the predominate genus and *F. necrophorum* is the most prevalent species. Other Fusobacteria include *F. nucleatum*, *Fusobacterium gonidiaforum* and *Fusobacterium varium.* Other isolates recovered alone or in combination include pigmented *Prevotella*, *Bacteroides* spp. and *Peptostreptococcus* spp.[61]

Surgical drainage of purulent collection is warranted. Antimicrobial selection is similar to one outlined for deep neck abscesses.

Considerations for antimicrobial use for the treatment of polymicrobial aerobic-anaerobic URTI and Head & Neck infections

Environmental control is achieved by debridment of necrotic tissues, drainage the pus, improving circulation, alleviating obstructions, and increasing the tissue oxygenation. Hyperbaric oxygen (HBO) may also be useful.[62]

Surgical therapy is the most important and sometimes the only form of treatment required in many cases, whereas in others, it is an essential adjunct to the medical approach. It is utilized to drain abscesses, debride necrotic tissues, decompress closed space-infections such as sinuses, relieve obstructions, and correct underlying pathology. When not performed, the infection may persist, and serious complications may arise.

For an adequate management of mixed aerobic and anaerobic infections is necessary the administration of agents effective against both types of organisms. A number of factors should be considered when choosing appropriate antimicrobial agents. They should be effective against all target organism(s), induce little or no resistance, achieve sufficient concentration in the infected site, have safety record and appropriate dosage schedules, cause minimal toxicity and have maximum stability.

Antimicrobials may fail to cure the infection. Among the reasons for this are the development of bacterial resistance, achievement of insufficient tissue concentration, incompatible drug interactions, and the formation of an abscess.

The abscess environment is detrimental to many antimicrobials. The abscess capsule may interfere with the antimicrobials penetration, and the low pH inside the abcess and high content of binding proteins or inactivating enzymes (i.e., beta-lactamase) may impair their activity.[46] The low pH and the anaerobic environment are especially unfavorable for the aminoglycosides and fluroquinolones.[63] However, an anaerobic environment, an acidic pH, and high osmolarity, can also develop in an infection site in the absence of an abscess.

The selection of antimicrobials should be guided by their aerobic and anaerobic antibacterial spectrum and their availability in oral or parenteral presentation. Some antimicrobials have a narrow spectrum of activity. For example, metronidazole is effective only against most anaerobes and therefore cannot be administered as a single agent for the therapy of mixed infections. Others (i.e., carbapenems) possess a wide spectrum of activity that includes also *Enterobacteriaceae*.

The selection of antimicrobials is simplified when reliable culture results are available. However, this may not always possible because of the problems in obtaining appropriate specimens. Many patients are therefore treated empirically based on suspected, rather than known pathogen(s). Fortunately, the types of anaerobes involved in most infections and their antimicrobial susceptibility patterns tend to be predictable, although they may vary in particular settings. Some anaerobes, however, have become resistant to selected antimicrobials or may become so while a patient is receiving therapy.[64]

Controversies exist regarding the need to provide coverage against all resistant isolates as some studies of the treatment of acute maxillary sinusitis suggested that utilization of narrow spectrum antimicrobials were as effective as wide spectrum ones. [65] However, other studies demonstrated the superiority of more effective agents to reach both clinical and bacteriological success. [66]

The choice of antimicrobial therapy is also influenced by factors other than susceptibility patterns. These include the pharmacokinetics (PK) and pharmacodynamics (PD), characteristics of the various drugs, their toxicity, their effect on the normal flora, and bactericidal activity. The clinical setting and Gram-stain preparation of the specimen may suggest what types of anaerobes are present as well as the nature of the infectious process.

The duration of therapy for anaerobic infections, which are often chronic, is generally longer than for infections due to aerobic and facultative bacteria. Duration of treatment also must be individualized, depending on the response. Oral therapy is often substituted for parenteral therapy after an initial period.

Additional information about anaerobic infections can be obtained at the author's Web Site: http://anaerobicinfections.blogspot.com/

Additonal information about sinusitis can be obtained at the author's Web Site: http://sinusitisunderstood.blogspot.com/

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