

Aim: To reduce unwarranted resource utilization and reduce variation in management of patients with suspected meningitis.

Patient with signs/symptoms concerning for meningitis which may include:

- Fever
- Meningeal signs (headache, neck pain/stiffness, photophobia, irritability)
- Vomiting
- Altered mental status
- Seizure

Transfer promptly to ED if in clinic; in ED:

- Full vital signs, BP, O2 sats, place PIV
- Analgesia and antipyretics if indicated
- Manage sepsis if indicated ([See sepsis guideline](#))
- Indications for urgent PICU management:
 - Moderately altered mental status (sustained GCS < 13) or declining exam
 - Concerns for increased ICP
 - Seizure
 - Persistent vomiting
 - Cardio respiratory instability
 - Abnormal neuro imaging

EXCLUSION GUIDELINES FOR PAGES 1-4*:

***Audiology screening on page 5-6 is relevant for all patients with confirmed meningitis (viral or bacterial).**

Patients **excluded** from this guideline pages 1-4:

- Infants <29 days age (separate [febrile infant guideline](#)) or in the NICU
- Well-appearing infants with fever age 29–60 days without specific concern for meningitis
- Immunosuppressed patients
- Mechanical device, including indwelling catheter, VP shunt, auditory prosthesis
- Recent neurosurgery

Initial studies

- CBC w/ diff, CRP, ESR, procalcitonin, CMP, blood culture. Consider lactate, blood gas, coags per [sepsis guideline](#)
- Lumbar puncture. Consider neuroimaging prior to LP if any clinical signs increased intracranial pressure (See note 1). Other contraindications to lumbar puncture may include coagulopathy, or local skin infection or hematoma at site of LP.
 - Obtain opening pressure
 - Send CSF for: cell count and diff, gram stain and culture, protein, glucose, meningitis/encephalitis panel, and tube of CSF to save (See note 1)
- Consider UA/Ucx
- Consider Lyme, HSV, TB, malaria testing if risk factors (See note 2)
- If patient is on oral or IV antibiotics currently, or has been in the past 72 hrs, please discuss with ID.

DISCHARGE CONSIDERATIONS:

- Not ill-appearing, no altered mental status, no petechiae or purpura on examination, not pretreated with antibiotics in the prior 72 hrs (including oral), and no other concerning symptoms
- No barriers to follow-up within 24–48 hours
- Tolerating PO
- Pain controlled on oral analgesics

Is there high clinical suspicion for bacterial meningitis or is patient critically ill?

No

Does the patient have CSF WBC ≥ 10 PLUS any of the following?

Any of these criteria infer higher likelihood for meningitis requiring antimicrobial therapy. Score not validated if patient on antibiotics (including oral) within prior 72 hours. LP may be more difficult to interpret in the setting of recent antibiotics so would have low threshold to discuss with ID.

- ☐ CSF gram stain positive for bacteria
- ☐ CSF absolute neutrophil count (ANC) ≥ 1,000 cells/mm³ (=CSF WBC count/% neutrophils in CSF)
- ☐ CSF protein ≥ 80 mg/dL
- ☐ Peripheral blood ANC ≥ 10,000 cells/mm³
- ☐ Seizure at (or prior to) initial presentation
- ☐ Procalcitonin >1.2 ng/mL
- ☐ CRP >4.0 mg/dL

Yes

Initiate promptly:

- 1. Antimicrobials** - see table 1 for dosing
 - Ceftriaxone IV
 - Vancomycin IV
 - Add acyclovir IV if concern for HSV
- 2. Dexamethasone** if patient ≥ 6 weeks (See note 5)

Admit patient. (Admit to PICU if: seizure, hemodynamic instability, altered mental status, concerns for increased ICP, abnormal neuro imaging, or need for intensive nursing cares/monitoring.)

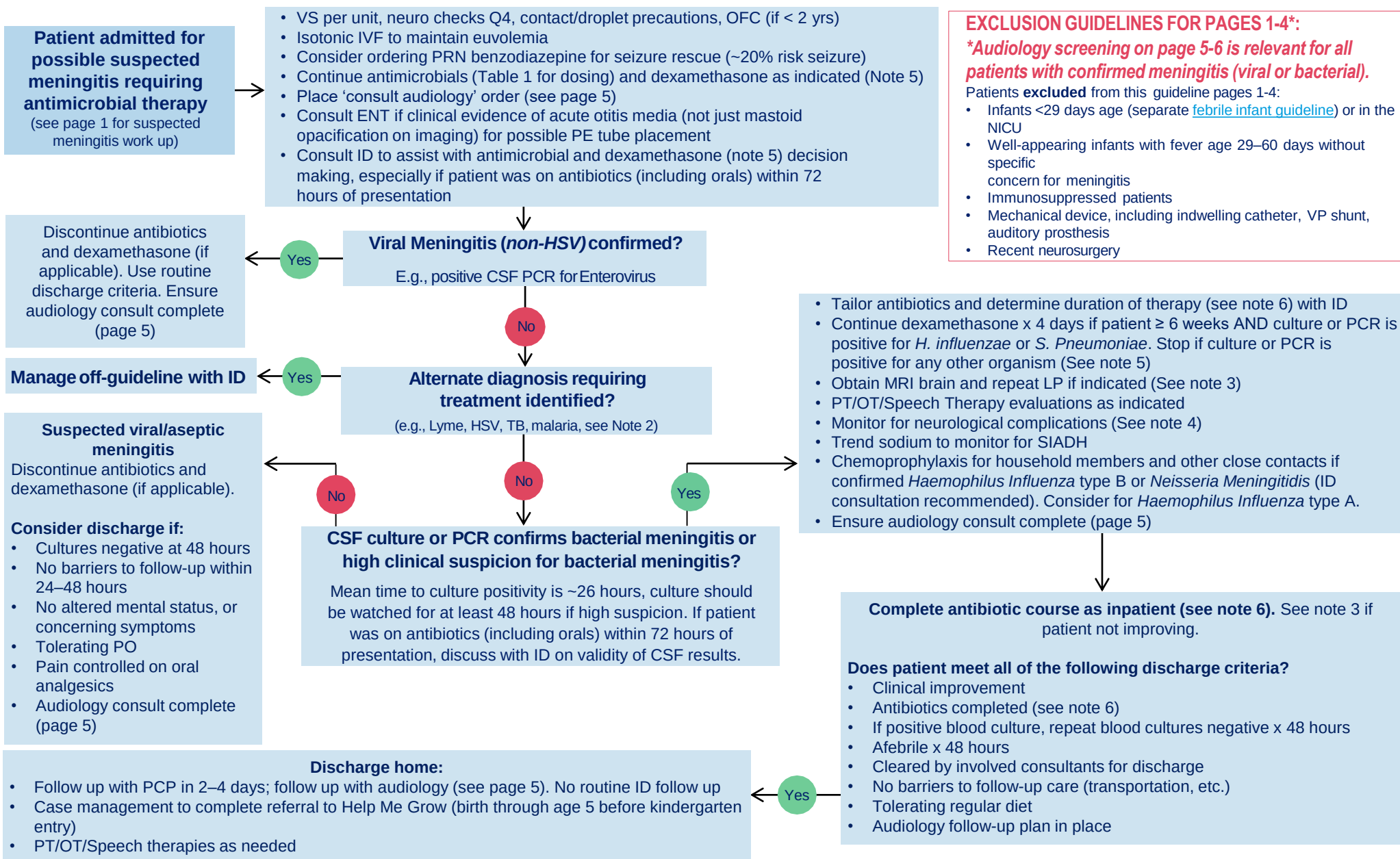
See page 2 for inpatient care.

No

Low likelihood (<1%) of meningitis requiring antimicrobial therapy

Consider discharge

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NOTE 1: LP/CSF testing/Head CT.

- Recommended to preform cranial imaging (Head CT) prior to LP in patient with: focal neurologic signs, cranial nerve deficits, papilledema, new-onset seizures, severely altered mental status (defined as a score on the Glasgow Coma Scale of <10), and severely immunocompromised state.
 - When lumbar puncture is deferred, blood samples should be collected and antimicrobial treatment started as soon as possible, prior to head imaging.
- Minimum CSF volumes: cell count and diff 0.5 ml, glucose 0.6 ml, protein 0.6 ml, culture/gram stain 0.5 ml, meningitis/encephalitis panel 0.25 ml. Saved sample should be refrigerated.
- With suspected traumatic lumbar puncture, adjustments of CSF WBC for RBC are poorly validated and should not be used to rule out meningitis. Some note that CSF WBC can be adjusted for RBC with 1:500 ratio (WBC:RBC)

NOTE 2: Risk factors for specific meningitis pathogens:

- Lyme: tick bite several weeks to a few months ago. Lyme meningitis will be covered by ceftriaxone.
- HSV meningitis is associated with primary genital HSV. HSV encephalitis presents with fever, altered mental status, altered level of consciousness, new onset seizure, or focal neurologic deficits.
- TB: subacute presentation (often more than 1 week), altered consciousness, personality changes, cranial nerve palsies common. May not have history of pulmonary disease.
- Parechovirus: cause of meningoencephalitis in infants < 3 months. May have rash; tachycardia out of proportion to fever; concurrent URI symptoms, abdominal distension, diarrhea; skin mottling; apnea (especially in premature infants); seizures common in < 3 months. Expect no CSF pleocytosis.

NOTE 3: Brain imaging and repeat LP

- Brain MRI: not routinely recommended but can be considered in the following cases. Ideal timing of MRI not well defined. If obtained, should ideally be performed with contrast.
 - Complicated course including decline in consciousness, new focal neurologic deficits, new seizure especially occurring after the first 72 hrs of treatment, no clinical improvement within 48hrs, increasing head circumference or bulging fontanelle (in infant)
 - Certain pathogens including Cronobacter, Citrobacter, S. aureus
 - Persistently positive CSF cultures
 - Neonates or older infants with typical neonatal pathogens (GBS, enteric gram negs, listeria) even if uncomplicated clinical course since clinical clues can be limited and more prone to complicated infection (based on expert opinion).
- Repeat LP recommended in the following scenarios:
 - Gram negative meningitis: in neonates, all should have repeat LP at 48-72 hrs into therapy
 - GBS meningitis: in neonates, consider repeat LP at 24-48 hrs into therapy.
 - Pneumococcal meningitis: consider repeat LP at 48-72 hrs into therapy if the isolate is ceftriaxone non-susceptible, if the patient's condition has worsened/not improved, **or if the patient has received dexamethasone** (which may interfere with ability to mount fever and trend clinical response.) Theoretical concern that the penetrance of vancomycin across the blood brain barrier is reduced when dexamethasone is given concomitantly.

NOTE 4. Potential neurological complications of meningitis include cerebral edema, subdural effusion, seizures, hearing loss, cranial nerve palsy, motor impairment, cerebrovascular complications, hydrocephalus, intellectual disability, mood disorder, attention deficit disorder, hypothalamic dysfunction.

Table 1. Meningitis-related Treatment Options and Dosing

Medication	Dosing	Indication
Antimicrobials [¥]		
Ceftriaxone	50 mg/kg (Max 2000 mg/dose) IV every 12 hours	All patients except those with relevant allergies. May still utilize in patients with Type I penicillin allergy. Do not use for Type II-IV penicillin allergy or Type I-IV cephalosporin allergy (consult ID). See Beta-Lactam Allergy Guideline
Vancomycin	1 month to < 3 months of age: 15 mg/kg IV every 12 hours 3 months to 18 years of age: 20 mg/kg (Max 1250 mg/dose initially) IV every 8 hours 18 – 24 years old: 15 mg/kg (Max 1250 mg/dose initially) IV every 8 hours	All patients
Acyclovir	< 3 months of age: 20 mg/kg IV every 8 hours 3 months to 11 years of age: 15 mg/kg IV every 8 hours ≥ 12 years of age: 10 mg/kg IV every 8 hours	Only for concerns for HSV
*Alternative antibiotic treatments		
Meropenem	40 mg/kg (Max 2000 mg/dose) IV every 8 hours	If Type I cephalosporin allergy. See Beta-Lactam Allergy Guideline . Consult Infectious Disease
For patients with a Type II – IV penicillin or cephalosporin allergy, consult Infectious Disease. See Beta-Lactam Allergy Guideline		
Corticosteroids		
Dexamethasone	0.15 mg/kg (Max 10 mg/dose) IV every 6 hours for 4 days	See Note 5 for indications. First dose should be administered 10-20 minutes prior to or concomitantly with the first dose of antibiotics. Can be started up to 4 hrs after initiation of antibiotics.

¥ "For patients who are under vaccinated or unvaccinated, there are no modifications recommended to antibiotic treatment.

NOTE 5. Adjunctive Corticosteroids (Dexamethasone)

- If there is high suspicion for bacterial meningitis in a patient ≥ 6 weeks, begin dexamethasone IV 0.15 mg/kg (max dose 10 mg/dose) q6 hours. This should be started as soon as possible but can be started up to 4 hrs after antibiotics. DO NOT DELAY antibiotics while considering corticosteroids. Do not give if concern for any other cause of meningitis (ex. TB meningitis, HSV, other viral)
- Dexamethasone should be promptly stopped if an etiology other than *H. influenzae* or *S. pneumoniae* is determined, including a viral meningoencephalitis (ex. gram stain suggests a different organism (H flu appear as gram negative coccobacilli, strep pneumo appear as gram positive cocci in pairs), or PCR/culture positive for another etiology).
- Benefits of corticosteroids:
 - *H. influenzae*: Dexamethasone use in infants and children with HiB meningitis has been shown to diminish the risk of hearing loss, if administered before or concurrently with the 1st dose of antimicrobial agents⁵⁶
 - *S. Pneumoniae*: In children with pneumococcal meningitis, dexamethasone may reduce mortality. Dexamethasone is recommended in adults (patients ≥ 16 years of age) with suspected or proven pneumococcal meningitis, as there is a mortality benefit and reduced hearing loss.
 - Risks of corticosteroids: Recurrent (rebound) fever has been shown to be more common with corticosteroids. This may lead to increased testing and imaging.

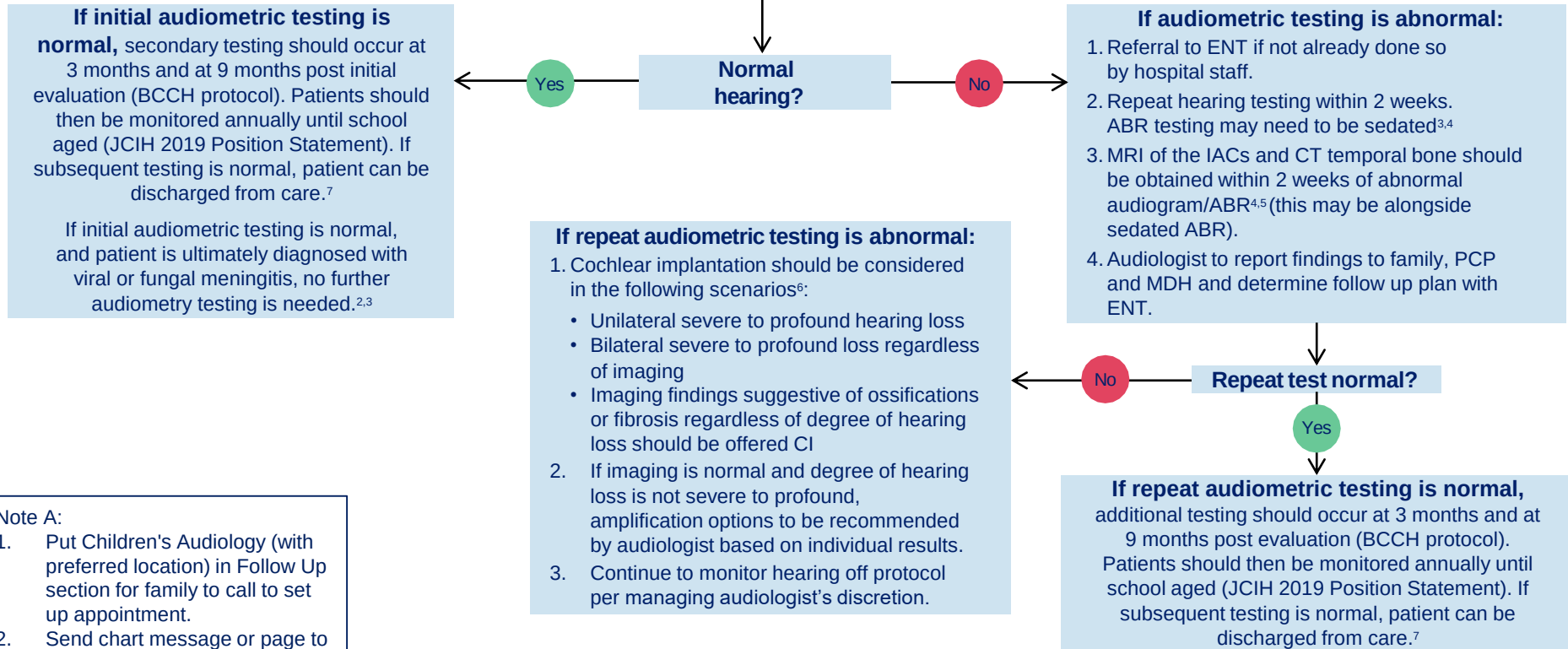
NOTE 6. Duration of therapy: ranges denote typical minimum duration of IV antibiotics. Should be determined for each patient by primary team and ID consultants and other involved specialists.

- *S. pneumoniae* – 10 to 14 days
- *N. meningitidis* – 7 days
- *H. influenzae* – 10 days
- *L. monocytogenes* – 21 to 28 days
- *S. agalactiae* – 14 days
- *S. aureus* – At least two weeks
- Gram-negative bacilli – Three weeks or a minimum of two weeks beyond the first sterile CSF culture, whichever is longer

Child admitted to hospital with viral or bacterial meningitis (or suspected meningitis). Hospital staff to place 'Audiology Consult' order as soon as meningitis diagnosis is made.

(Hospital staff: no need to page)

Audiometric testing to occur as soon as acute phase of illness has subsided/patient is stable. Testing type to be determined by audiologist (Diagnostic ABR vs Behavioral Testing). Viral or fungal meningitis should complete a single AABR screen or behavioral test (age dependent). If confirmed viral meningitis, ok to complete audiology consult outpatient if needed (see Note A).^{2,3,4}



Note A:

1. Put Children's Audiology (with preferred location) in Follow Up section for family to call to set up appointment.
2. Send chart message or page to ENT on call so they can forward to their scheduling team.

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AUDIOLOGY/ENT NOTES

NOTE A. Incidence of post-meningitic hearing loss varies from 2-35% (Rodenburg-Vlot et al., 2015). A systematic review of the literature showed an incidence of hearing loss (>25.5 dB) of 14% and an incidence of 5% for profound hearing loss (>90 dB) (Rodenburg-Vlot et al., 2016). Although hearing loss may improve, fluctuate, or deteriorate, the majority of hearing losses are likely to be stable.

Limited by poor methodology/standardized audiometric care in most studies

NOTE B. Bacteria most likely to cause hearing loss and ossifications are: *Streptococcus pneumoniae*, *Neisseria meningitidis*, and *Haemophilus influenzae* (BCCH protocol). The evidence does not suggest that viral meningitis or fungal meningitis have high incidence of hearing loss, however, a single screening ABR (age appropriate) or behavioral testing should be performed on these patients until better data exists (they do not need to follow the next steps for follow up in this protocol if normal hearing confirmed).

NOTE C. The Rodenburg-Vlot et al. 2016 systemic review found that hearing loss after bacterial meningitis predominantly seems to be of early onset, therefore all patients should be tested as soon as the acute phase is over (and at the latest at discharge). Ossifications can occur within 2-4 weeks after initial infection (BCCH protocol). Rodenburg-Vlot et al. (2018) suggested long-term audiological follow-up is only needed for the patients who develop a hearing loss during the meningitis, as patients with initial normal hearing after meningitis showed stable normal hearing over time; however at Children's Minnesota, we will monitor more conservatively based on the BCCH protocol and JCIH recommendations listed below.

NOTE D. Ear specific behavioral testing including speech testing should be completed on all meningitis patients, or a diagnostic ABR if age or compliance are limited (De Barros et al. 2014). Auditory brainstem response testing (ABR) can often be completed without sedation under 3 months of age. However, sedation is typically required for this test after age 3 months. Consider coordinating with upcoming sedations. Otoacoustic emissions can be used as a supplementary objective test during auditory function tests, but should not be used in isolation (De Barros et al. 2014).

NOTE E. Both CT and MRI have a role

- In five cases with normal CT results, signs of ossification were seen on MRI (20%), whereas ossification was seen on CT in three cases with normal MRI (12%). Thus, the accuracy of both modalities appears inadequate (Caye-Thomasen, 2012)
- If early signs of fibrosis/ossifications, this can progress (Caye-Thomasen, 2012). Cochlear ossifications can occur within 4 weeks after meningitis and can significantly influence surgical complexity in cochlear implantation (Durisin, et al, 2010).
- MRI + CT = 94% sensitivity (Isaacson et al., 2009)
 - CT alone is 50%

NOTE F. Cochlear implantation should be considered in the following scenarios:

- Unilateral cases of severe to profound hearing loss
- Bilateral or unilateral severe to profound loss regardless of imaging
- Imaging findings suggestive of ossifications or fibrosis regardless of degree of hearing loss should be offered CI

NOTE G. British Columbia Children's Hospital (BCCH) recommends all patients diagnosed with bacterial meningitis who are initially follow to have normal hearing, repeat testing at 3 months post-infection, and then again 6 months after the first repeated test (9 months post-infection). The Joint Commission on Infant Hearing (JCIH) recommends all patients who are diagnosed with bacterial meningitis in infancy, have an initial diagnostic test and are monitored annually until school aged.

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