ED GUIDELINE

SUSPECTED MENINGITIS

Age 29 days–24 years

Children's MINNESOTA

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 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).
- If patient shows signs of critical illness: severely altered mental status, evidence of cerebral herniation, need for respiratory or blood pressure support, contact PICU physician ASAP.

EXCLUSION GUIDELINES FOR PAGES 1-3*:

Audiology screening on page 4-5 is relevant for all patients with confirmed meningitis (viral or bacterial).

Patients **excluded** from this guideline pages 1-3:

- 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. Add coags if concern for sepsis
- Lumbar puncture: obtain opening pressure if feasible. Consider neuroimaging prior to LP if any clinical signs increased intracranial pressure (See note 1)
  - If > 15 cm H2O, neuroimaging and consult PICU
  - Send CSF for: cell count and diff, gram stain and culture, protein, glucose, tube of CSF to save (See note 1)
  - Send meningitis/encephalitis panel in all patients <90 days of age, and those who have received antibiotics within the past 7 days
- Consider UA/Ucx
- Consider lactate, blood gas
- Consider Lyme, HSV, TB, malaria testing if risk factors (See note 2)

***If high clinical suspicion for bacterial meningitis, initiate antibiotics immediately,* otherwise may first determine likelihood of bacterial meningitis.**

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

(Note: the following criteria were validated in children <18 years of age)

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

Yes

Higher likelihood for meningitis requiring antimicrobial therapy.

Admit

No

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

Consider discharge

DISCHARGE CONSIDERATIONS:

- Not ill-appearing, no altered mental status, no petechaie 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

Admit to PICU if: seizure, hemodynamic instability, altered mental status, or need for intensive nursing cares/monitoring.

- Ceftriaxone 50 mg/kg IV x1 (See note 3)
- Vancomycin 20 mg/kg IV x1 (See note 3)
- Add acyclovir IV x 1 if concern for HSV (See note 3 for dosing)
- Corticosteroids may be considered under certain circumstances (See note 4)
  - If used, steroids should be given before/with antibiotics.

See page 2 for inpatient care.

INPATIENT GUIDELINE

SUSPECTED MENINGITIS

Age 29 days–24 years

Children's MINNESOTA

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

Patient admitted for possible suspected meningitis requiring antimicrobial therapy
(see page 1 for suspected meningitis work up)

- VS per unit, neuro checks Q4, contact/droplet precautions, OFC (if < 2 yrs)
- Isotonic IVF to maintain euvolemia
- Consider ordering PRN benzodiazepine for seizure rescue (~20% risk seizure)
- Continue antimicrobials (Note 3 for dosing)
- Place 'consult audiology' order (see page 4)
- Consult ENT if clinical evidence of acute otitis media (not just mastoid opacification on imaging) for possible PE tube placement

EXCLUSION GUIDELINES FOR PAGES 1-3*:

Audiology screening on page 4-5 is relevant for all patients with confirmed meningitis (viral or bacterial).

Patients **excluded** from this guideline pages 1-3:

- 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

Viral Meningitis (*non-HSV*) confirmed?

E.g., positive CSF PCR for Enterovirus

Yes → Discontinue antibiotics and steroids (if applicable). Use routine discharge criteria. Ensure audiology consult complete (page 4)

No ↓

Alternate diagnosis requiring treatment identified?

(e.g., Lyme, HSV, TB, malaria)

Yes → **Manage off-guideline**

No ↓

Culture or PCR confirms bacterial meningitis?

Mean time to culture positivity is ~26 hours, culture should be watched for at least 48 hours if high suspicion

No → **Suspected viral/aseptic meningitis**
Discontinue antibiotics and steroids (if applicable).

Consider discharge if:

- Cultures negative at 48 hours
- No barriers to follow-up within 24–48 hours
- No altered mental status, or
- concerning symptoms
- Tolerating PO, pain controlled on oral analgesics
- Audiology consult complete (page 4)

Yes →

- Consult ID and tailor antibiotics, determine duration of therapy (Note 7)
- Continue dexamethasone x 2 days if culture or PCR is positive for Hib (children) or *S. pneumo* (adults, patients ≥16 yrs). Stop if culture is any other organism.
- Obtain MRI brain if indicated (See note 5)
- PT/OT/Speech Therapy evaluations as indicated
- Monitor for neurological complications (See note 6)
- Trend sodium to monitor for SIADH
- Repeat LP if indicated (See note 5)
- Chemoprophylaxis for household members and other close contacts if confirmed *Haemophilis Influenza* type B or *Neisseria Meningitidis* (ID consultation recommended)
- Ensure audiology consult complete (page 4)

↓

Complete antibiotic course as inpatient (Note 7). See note 5 if patient not improving.

Does patient meet all of the following discharge criteria?

- Organism and susceptibilities resulted
- Antibiotics completed (Note 7)
- Normal neuroimaging, if obtained
- Normal neurological exam
- If positive blood culture, repeat blood cultures negative x 48 hours
- Afebrile x 48 hours
- No barriers to follow-up care (transportation, etc.)
- Tolerating regular diet
- Audiology follow-up plan in place

Yes →

Discharge home:

- Follow up with PCP in 2–4 days; follow up with audiology (see page 4). No routine ID follow up
- Case management to complete referral to Early Intervention
- PT/OT/Speech therapies as needed

SUSPECTED MENINGITIS

Age 29 days–24 years

Children's MINNESOTA

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

NOTE 1: LP/CSF testing.

- Recommended to preform cranial imaging prior to LP in patient with: focal neurologic deficits (excluding cranial nerve palsies), new-onset seizures, severely altered mental status (defined as a score on the Glasgow Coma Scale of <10) and severely immunocompromised state.
- Minimum CSF volumes: cell count and diff 0.5 ml min, glucose 0.6 ml, protein 0.6 ml, culture/gram stain min 0.5 ml meningitis/encephalitis panel 0.25 ml. Saved sample should be refrigerated.
- CSF WBC can be adjusted for a suspected bloody tap using a 1:500 ratio (WBC:RBC).
- The meningitis/encephalitis PCR panel should be sent in all patients <90 days of age, and those who have received antibiotics within the past 7 days.

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. Antimicrobial regimens

- Ceftriaxone: 50 mg/kg IV every 12 hours (max 2000 mg/dose). If cephalosporin allergy or type I penicillin allergy (anaphylaxis), use meropenem instead and consult ID.
    - Meropenem: 40 mg/kg IV q8h (max 2000 mg/dose)
- Vancomycin:
    - 20 mg/kg IV q8h if < 18 years old (Max 1250 mg/dose initially)
    - 15 mg/kg IV q8h if 18–24 years old (Max 1250 mg/dose initially)
- Acyclovir IV:
    - < 3 months: 20 mg/kg IV q8h
    - 3 months to 11 years old: 15 mg/kg IV every 8 hours
    - ≥12 years old: 10 mg/kg IV every 8 hours

NOTE 4. Adjunctive Steroids:

- Dexamethasone is beneficial for treatment of infants and children with HiB meningitis to diminish the risk of hearing loss, if administered before or concurrently with the 1st dose of antimicrobial agents
- For infants and children 6 weeks and older with pneumococcal meningitis, adjunctive therapy with dexamethasone is controversial and data are not sufficient to make a routine recommendation for children. Dexamethasone is recommended in adults (patients ≥16 yrs) with suspected or proven pneumococcal meningitis, as there is a mortality benefit.
- Dose: Dexamethasone 0.15 mg/kg/dose IV q6h for 2 days (max 10 mg per dose)
- First dose should be administered 10–20 minutes prior to, or concomitantly with the first dose of antibiotics.

NOTE 5. Brain imaging and repeat LP

- MRI: not routinely needed except if: complicated course, certain pathogens (e.g., Cronobacter, Citrobacter, S. aureus), persistently positive CSF, neonates or older infants with typical neonatal pathogens (GBS, enteric gram negs, listeria) since clinical clues can be limited.
- LP: Repeat at 24–48 hours if gram negative meningitis. Consider repeat at 24-48 hrs in GBS meningitis. For pneumococcal meningitis, repeat LP at 48-72 hours if the isolate is cefotaxime and ceftriaxone nonsusceptible, or if the patient's condition has worsened/not improved, or if the patient has received dexamethasone (which may interfere with ability to mount fever to trend clinical response).

NOTE 6. 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.

NOTE 7. Duration of therapy: ranges denote typical 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

SUSPECTED MENINGITIS – Audiology

Age 0 days–24 years

Children's MINNESOTA

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).[2,3,4]

Normal hearing?

Yes

If initial audiometric testing is normal, secondary testing should occur at 3 months and at 9 months post initial evaluation (BCCH protocol). Patients should then be monitored annually until school aged (JCIH 2019 Position Statement). If subsequent testing is normal, patient can be discharged from care.[7]

If initial audiometric testing is normal, and patient is ultimately diagnosed with viral or fungal meningitis, no further audiometry testing is needed.[2,3]

No

If audiometric testing is abnormal:

1. Referral to ENT if not already done so by hospital staff.
2. Repeat hearing testing within 2 weeks. ABR testing may need to be sedated[3,4]
3. MRI of the IACs and CT temporal bone should be obtained within 2 weeks of abnormal audiogram/ABR[4,5] (this may be alongside sedated ABR).
4. Audiologist to report findings to family, PCP and MDH and determine follow up plan with ENT.

Repeat test normal?

No

If repeat audiometric testing is abnormal:

1. Cochlear implantation should be considered in the following scenarios[6]:
   - Unilateral severe to profound hearing loss
   - Bilateral severe to profound loss regardless of imaging
   - Imaging findings suggestive of ossifications or fibrosis regardless of degree of hearing loss should be offered CI
2. If imaging is normal and degree of hearing loss is not severe to profound, amplification options to be recommended by audiologist based on individual results.
3. Continue to monitor hearing off protocol per managing audiologist's discretion.

Yes

If repeat audiometric testing is normal, additional testing should occur at 3 months and at 9 months post evaluation (BCCH protocol). Patients should then be monitored annually until school aged (JCIH 2019 Position Statement). If subsequent testing is normal, patient can be discharged from care.[7]

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

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 ossificans are: strep pneumo, neisseria meningitides, haemophilus influenza (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 f/u 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) suggestd 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 age 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/ossificans, 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 ossificans 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.

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

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