Preparedness and response to bacterial meningitis outbreaks

Toolkit for frontline healthcare workers

World Health Organization

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Abbreviations and acronyms

ABCDE	Airway, Breathing, Circulation, Disability and Exposure
AMR	antimicrobial resistance
AST	antibiotic susceptibility testing
AWaRe	Access, Watch and Reserve classification of antibiotics
CBC	complete blood count
CrAg	cryptococcal antigen
CSF	cerebrospinal fluid
GCS	Glasgow Coma Scale
HIV	human immunodeficiency virus
ICP	intracranial pressure
ID	identification
IM	intramuscular
IV	intravenous
NAAT	nucleic acid amplification test
PCR	polymerase chain reaction
PO	per os (by mouth)
RBC	red blood cell
RDT	rapid diagnostic test
SIADH	syndrome of inappropriate antidiuretic hormone secretion
T-I	trans-isolate
WHO	World Health Organization
WBC	white blood cell

Overview

Acute bacterial meningitis continues to pose a public health threat globally, despite successful prevention and control efforts in several regions of the world. The burden of mortality and morbidity, including the risk of neurological and physical sequelae, remains high, particularly in low- and middle-income countries as well as during large-scale epidemics and humanitarian emergencies.

With a view to eliminating meningitis as a public health problem, the World Health Organization (WHO) together with global partners and experts, coordinated the development of *Defeating meningitis by 2030: a global road map*, which was approved by the Seventy-third World Health Assembly (resolution WHA73.9).

Under this framework, the *WHO guidelines on meningitis diagnosis, treatment and care* were published to provide evidence-based recommendations for the clinical management of children over 1 month of age, adolescents and adults with acute, community-acquired meningitis.

Recognizing the urgent need to translate these recommendations into implementation guidance, particularly in high-risk and resource-constrained settings, WHO has developed a toolkit designed as a suite of job aids to inform clinical activities at the point of care.

The toolkit serves as a practical resource for frontline healthcare professionals, including in the African meningitis belt region and humanitarian settings, where the risk of outbreaks and excess mortality due to acute bacterial meningitis is highest. This publication is intended for use by a broad spectrum of healthcare providers working in primary, secondary, and tertiary facilities, including medical doctors, nurses, and other clinicians routinely involved in the care of individuals with meningitis.

With a primary focus on acute bacterial meningitis in children aged over 1 month, adolescents and adults, the toolkit provides guidance on the causative pathogens, clinical manifestations, diagnostic investigations, antibiotic therapy, adjunctive treatment, supportive care, and post-exposure prophylaxis. In addition, it includes some considerations on viral, tuberculous and cryptococcal meningitis, due to shared clinical features and overlapping diagnostic and treatment strategies.

Methods

The WHO Technical Team developed the content of this publication based on existing WHO guidelines, norms and standards. A list of relevant resources used as references can be found in the Bibliography. In addition, technical experts from relevant departments at WHO headquarters, regional and country offices were consulted to ensure the document reflects multidisciplinary expertise and aligns with current recommendations and practices.

A group of external experts was established to review, validate and provide technical input into the draft document. The group comprised a diverse group of individuals with relevant experience in clinical practice, infectious diseases and microbiology and was selected with careful consideration of gender and geographical balance.

In accordance with WHO procedures for declarations of interest, all members of the panel were asked to declare in writing any competing interests (academic, financial or other) at the time of the invitation to participate in the development process. The standard WHO declaration of interest forms were completed, signed by each expert and assessed by the WHO Technical Team.

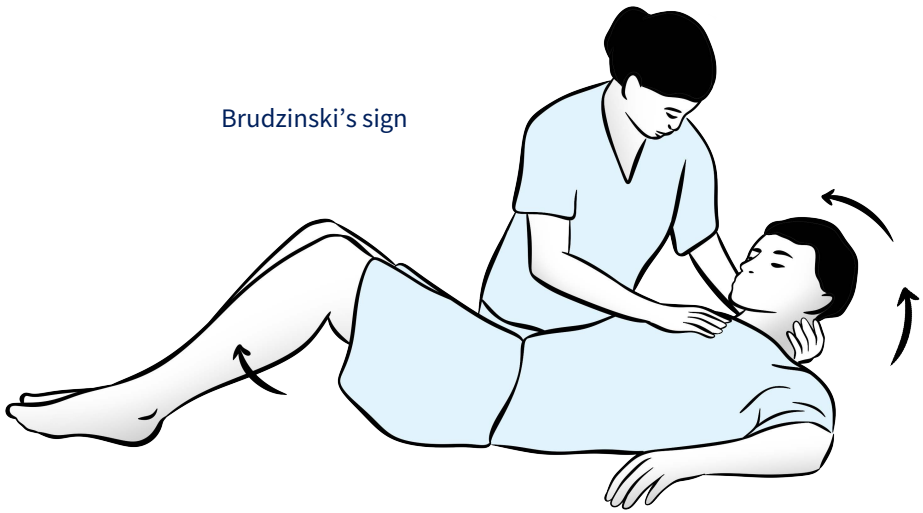
Causative pathogens of acute bacterial meningitis

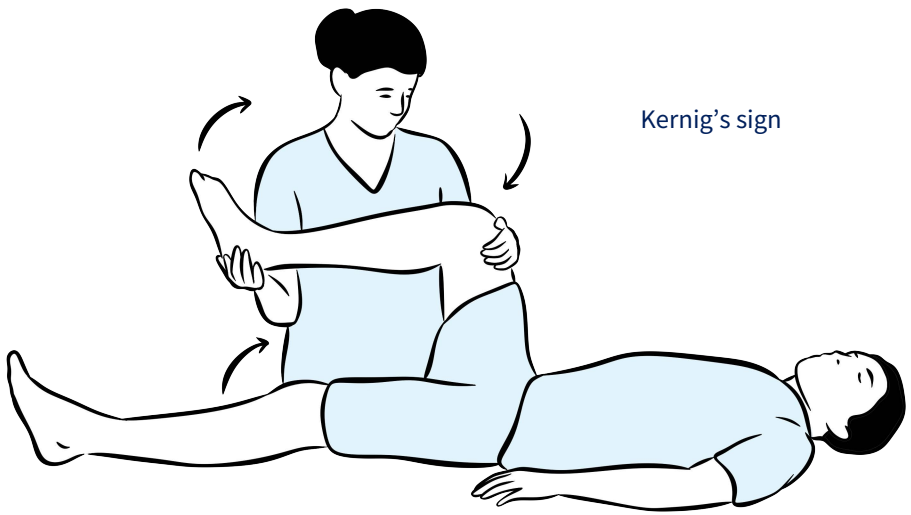
Bacterial pathogen	Transmission	Age groups[a]	Main predisposing conditions
Streptococcus pneumoniae	Person-to-person through infectious respiratory particles	All ages Most common cause in adults	Contiguous infectious focus (e.g. otitis media, mastoiditis, sinusitis) Head trauma with skull base fracture Anatomical or functional asplenia (e.g. post-splenectomy, sickle cell disease) Immunocompromised state with reduced humoral immunity[b]
Neisseria meningitidis	Person-to-person through infectious respiratory particles	All ages Leading cause in children and young adults	Nasopharyngeal colonization Anatomical or functional asplenia (e.g. post-splenectomy, sickle cell disease) Complement component deficiencies or inhibitors HIV infection
Listeria monocytogenes	Foodborne	Neonates Older adults	Immunocompromised state[c] Pregnancy
Streptococcus agalactiae	Intrapartum or postpartum Person-to-person through direct contact	Neonates and children <3 months Older adults	Colonization of maternal genital tract during pregnancy Intraamniotic infection Preterm birth
Haemophilus influenzae (type b)[d]	Person-to-person through infectious respiratory particles	Children <5 years	Incomplete or no vaccination Anatomical or functional asplenia (e.g. post-splenectomy, sickle cell disease) Immunocompromised state with reduced humoral immunity[b]
Non-typhoidal *Salmonella*	Faecal-oral (foodborne, waterborne, person-to-person)	Neonates and children ≤12 months	Haemoglobinopathies (e.g. sickle cell disease) HIV infection Malaria with severe anemia Malnutrition

[a] The scope of this document pertains to children older than 1 month and adults; neonates are included in this table for reference only.
[b] B-cell lymphoproliferative disorders (e.g. lymphoma, multiple myeloma), HIV infection, immunosuppressive therapy (e.g. chemotherapy, radiation therapy), primary humoral immunodeficiencies (e.g. agammaglobulinemia, common variable immunodeficiency).
[c] Advanced HIV disease, alcohol use disease, diabetes mellitus, end-stage kidney disease, immunosuppressive therapy, liver cirrhosis, malignancy, organ transplantation.
[d] Non-typeable and non-b encapsulated strains of *H. influenzae* can cause meningitis across all age groups, particularly in young children and older adults.

Clinical manifestations of acute bacterial meningitis

General considerations	
Acute bacterial meningitis is a medical emergency that presents abruptly and can be rapidly evolving.	
The clinical presentation may be difficult to differentiate from other infections, including cerebral malaria, viral meningitis and, in selected cases, tuberculous and cryptococcal meningitis.	
Signs and symptoms of a central nervous system infection	
Fever (body temperature ≥38.0°C)	
Altered mental status (from confusion to impaired consciousness and coma)	
Headache	
Signs of meningeal irritation	
Neck stiffness (nuchal rigidity)	Inability to touch the chin to the chest upon flexion of the neck (antero-posterior neck motion more reliable than lateral motion)
Brudzinski's sign	Involuntary flexion of the hips upon passive flexion of the neck
Kernig's sign	Inability to allow full extension of the knee upon 90° flexion of the hip, associated with flexion of the opposite knee
Photophobia	Documented sensitivity to light





Clinical manifestations of acute bacterial meningitis

General considerations
Bacterial meningitis should be strongly suspected with the acute onset (<48 hours) of all of the following manifestations: fever, neck stiffness, and altered mental status or headache (classic meningitis triad).
Approximately 50% of adults with bacterial meningitis present with the classic meningitis triad, and its absence cannot be used to rule out bacterial meningitis.
Signs of meningeal irritation (e.g. neck stiffness, Brudzinski's sign, Kernig's sign, photophobia) should always be investigated, but their absence cannot be used to rule out bacterial meningitis.
Malaise, fatigue, nausea, vomiting, abdominal pain and/or back pain may often occur, including in early disease.
Focal neurological deficits (e.g. aphasia, hemiparesis or monoparesis) and cranial nerve palsies may indicate concurrent parenchymal involvement and are more commonly associated with bacterial infections (i.e. bacterial meningoencephalitis).
Seizures may occur in both children and adults. In adults, seizures might be associated with concurrent parenchymal involvement (i.e. bacterial meningoencephalitis).
Some clinical manifestations can provide insights into the most likely causative pathogen. A non-blanching petechial or purpuric skin rash is suggestive of meningococcal infection (meningococcemia).
Infants and young children
The clinical presentation is variable and less characteristic; neck stiffness and headache are less frequent or harder to identify.
Common manifestations are fever or hypothermia, bulging fontanelle, seizures, abnormal cry, irritability, lethargy, reduced feeding, vomiting, diarrhoea and respiratory distress (e.g. apnoea, tachypnoea, grunting).
Increased intracranial pressure
Some people may present with symptoms and signs of increased intracranial pressure.
Suggestive manifestations include severe headache, vomiting, depressed consciousness, cranial nerve deficit (e.g. VI), papilloedema, and/or a triad of bradycardia, hypertension and respiratory depression.
Based on available resources and capacities, an ophthalmoscope can be used to detect or rule out papilloedema (optic disc swelling).
Sepsis and septic shock
Bacterial meningitis may occur at the same time as, or rapidly progress to, sepsis.
In severe cases, septic shock, multiorgan failure or disseminated intravascular coagulation can occur.
Purpura fulminans is defined as the presence of acute-onset, life-threatening skin haemorrhage and gangrene due to disseminated intravascular coagulation.

Initial management of people with suspected acute bacterial meningitis

Management before referral to an appropriate health-care facility

Adult or child with suspected acute bacterial meningitis in a health-care facility
where lumbar puncture cannot be performed and management of severe illness cannot be ensured

Assess and stabilize (ABCDE)
Start managing acute illness and ensure appropriate fluid management

Perform a parasitological test for malaria (in endemic areas) and treat accordingly | Test for HIV
Organize prompt and safe referral or transfer to an appropriate health-care facility[a] for further management

Is a clinically significant delay in transfer expected (door-to-door time >30 minutes)?

Yes

Administer IV or IM ceftriaxone STAT
(2 g in adults; 50 mg/kg in children)[b-d]

Consider IV dexamethasone STAT in selected cases (10 mg in adults; 0.15 mg/kg in children)[e]

Refer the person to an appropriate health-care facility[a] as soon as possible

No

Refer the person to an appropriate health-care facility[a] as soon as possible

Fluid management

- Use Ringer's lactate or normal saline for IV fluid resuscitation.
- Do not use glucose-based solutions unless hypoglycaemia is also a concern.
- Avoid overhydration and fluid restriction.

Malaria testing and management in endemic areas

- Cerebral malaria and acute bacterial meningitis can present with similar clinical features.
- In malaria-endemic areas, perform a malaria test (microscopy or RDT) in all people suspected of having cerebral malaria or acute bacterial meningitis.
  - If malaria testing is positive, start parenteral antimalarial treatment, in parallel to acute bacterial meningitis workup and management.
  - If malaria testing is negative, do not start parenteral antimalarial treatment and continue acute bacterial meningitis workup and management.

Pre-referral antibiotic treatment

- Administer pre-referral antibiotics only when acute bacterial meningitis is strongly suspected and a clinically significant delay in transfer is likely (>30 minutes from door to door).
- Do not administer pre-referral antibiotics indiscriminately or when transfer can be swiftly ensured without a clinically significant delay (<30 minutes from door to door).

ABCDE: Airway, Breathing, Circulation, Disability and Exposure. IM: intramuscular. IV: intravenous. RDT: rapid diagnostic test.

[a] Appropriate health-care facility: lumbar puncture can be performed when indicated and adequate monitoring and management of severe illness can be ensured.

[b] Prefer IV administration. If IV administration is not possible and/or an IV line cannot be secured, proceed with IM administration.

[c] When no meningococcal or pneumococcal disease outbreak is ongoing, consider adding parenteral ampicillin in people presenting with ≥1 risk factor for *Listeria monocytogenes* infection (i.e. age >60 years, pregnancy or immunocompromised state).

[d] When no meningococcal disease outbreak is ongoing, consider adding IV vancomycin in the presence of a high baseline prevalence of *Streptococcus pneumoniae* resistant to penicillins or third-generation-cephalosporins at the national or sub-national level.

[e] Consider pre-referral dexamethasone when all of the following conditions apply: 1) Pre-referral antibiotic therapy is administered; 2) Cerebral malaria is excluded; 3) Cryptococcal meningitis is not a likely diagnosis (e.g. the person is not known or suspected to have advanced HIV disease); 4) There is no ongoing meningococcal disease outbreak

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Initial management of people with suspected acute bacterial meningitis

Management in an appropriate health-care facility (Scenario 1)

Adult or child with suspected acute bacterial meningitis
in an appropriate health-care facility[a] without readily accessible cranial imaging[b]

Assess and stabilize (ABCDE)
Start managing acute illness and acute complications

Collect blood samples for cultures, HIV test and context-appropriate investigations[c]
Perform a parasitological test for malaria (in endemic areas) and treat accordingly
Assess for lumbar puncture contraindications (absolute and relative)

No absolute or relative contraindications	No absolute contraindications but any relative contraindication	Any absolute contraindication
Perform lumbar puncture and test CSF samples[d]	Start IV treatment as soon as possible and within 1 hour of admission	Start IV treatment as soon as possible and within 1 hour of admission
Start IV treatment as soon as possible and within 1 hour of admission	Defer lumbar puncture and reassess the need if relative contraindications resolve	

Absolute contraindications to lumbar puncture

- Ongoing haemodynamic compromise (until stabilized)
- Ongoing respiratory failure (until stabilized)
- Severe bleeding disorder
- Skin or soft tissue infection overlying or close to puncture site
- Epidural abscess close to puncture site

Relative contraindications to lumbar puncture

- GCS < 10
- Focal neurological signs
- Cranial nerve deficits
- Papilloedema
- New-onset seizures (in adults)
- Severe immunocompromised state

Treatment timing

- Start treatment as soon as possible and within 1 hour of admission (door-to-antibiotic time).
- Do not delay treatment initiation if there is any delay in lumbar puncture or diagnostic investigations.

ABCDE: Airway, Breathing, Circulation, Disability and Exposure. CSF: cerebrospinal fluid. GCS: Glasgow Coma Scale.

[a] Appropriate health-care facility: lumbar puncture can be performed when indicated and adequate monitoring and management of severe illness can be ensured.

[b] Readily accessible cranial imaging: cranial CT or MRI are available and clinical expertise to interpret imaging findings is ensured.

[c] Blood investigations: cultures (at least one set); HIV test; glucose; complete blood count (where resources allow); C-reactive protein and procalcitonin (where resources allow); additional investigations based on clinical considerations and available resources (e.g. electrolytes; kidney and liver function tests; coagulation studies; lactate; selected disease-specific serology and antigen tests; molecular tests).

[d] CSF investigations: culture and molecular tests; Gram stain; total and differential white blood cell count; red blood cell count; total protein; glucose; lactate (prior to antibiotic therapy and if resources allow); bacterial antigen tests (for outbreak detection and response); additional disease-specific investigations based on epidemiological and clinical considerations (e.g. molecular test for tuberculous meningitis; cryptococcal antigen test for cryptococcal meningitis).

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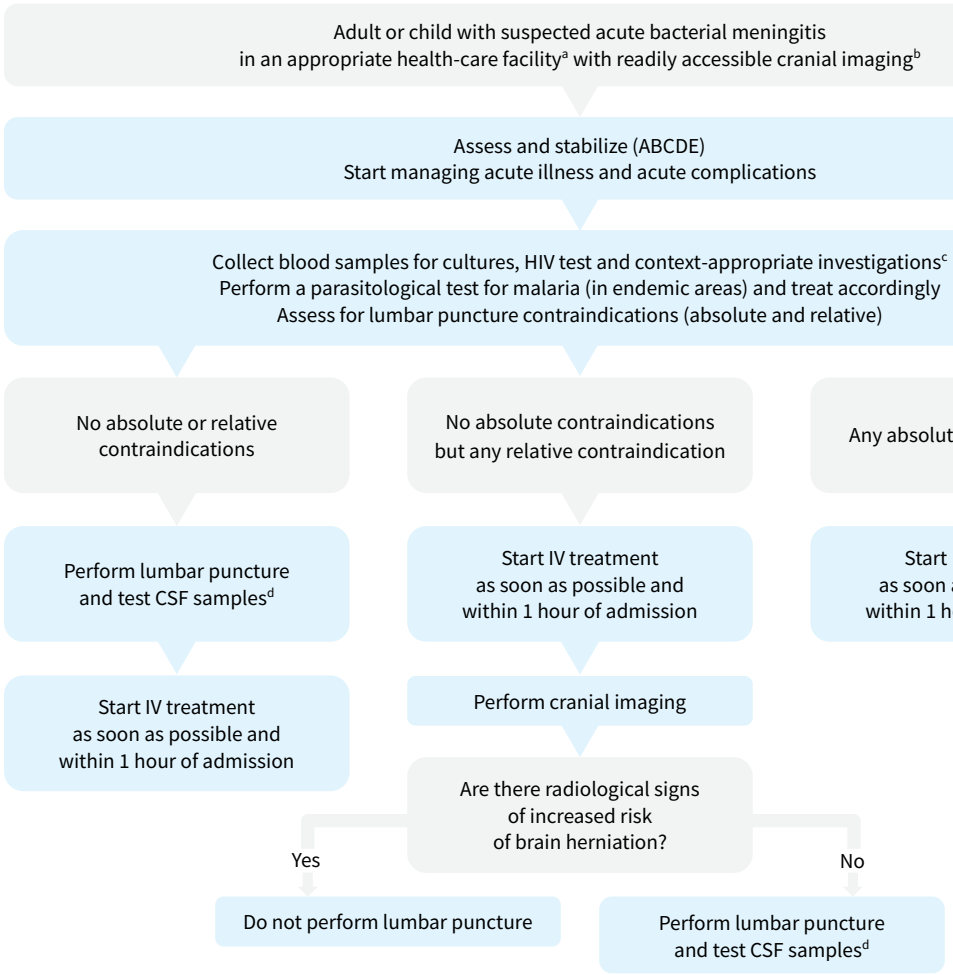
Initial management of people with suspected acute bacterial meningitis

Management in an appropriate health-care facility (Scenario 2)



Absolute contraindications to lumbar puncture

- Ongoing haemodynamic compromise (until stabilized)
- Ongoing respiratory failure (until stabilized)
- Severe bleeding disorder
- Skin or soft tissue infection overlying or close to puncture site
- Epidural abscess close to puncture site

Relative contraindications to lumbar puncture

- GCS < 10
- Focal neurological signs
- Cranial nerve deficits
- Papilloedema
- New-onset seizures (in adults)
- Severe immunocompromised state

Radiological signs of increased risk of brain herniation

- Brain space-occupying lesions with midline shift
- Diffuse and/or severe cerebral oedema
- Obstructive hydrocephalus

Treatment timing

- Start treatment as soon as possible and within 1 hour of admission (door-to-antibiotic time).
- Do not delay treatment initiation if there is any delay in lumbar puncture or while awaiting cranial imaging.

ABCDE: Airway, Breathing, Circulation, Disability and Exposure. CSF: cerebrospinal fluid. GCS: Glasgow Coma Scale.

[a] Appropriate health-care facility: lumbar puncture can be performed when indicated and adequate monitoring and management of severe illness can be ensured.

[b] Readily accessible cranial imaging: cranial CT or MRI are available and clinical expertise to interpret imaging findings is ensured.

[c] Blood investigations: cultures (at least one set); HIV test; glucose; complete blood count (where resources allow); C-reactive protein and procalcitonin (where resources allow); additional investigations based on clinical considerations and available resources (e.g. electrolytes; kidney and liver function tests; coagulation studies; lactate; selected disease-specific serology and antigen tests; molecular tests).

[d] CSF investigations: culture and molecular tests; Gram stain; total and differential white blood cell count; red blood cell count; total protein; glucose; lactate (prior to antibiotic therapy and if resources allow); bacterial antigen tests (for outbreak detection and response); additional disease-specific investigations based on epidemiological and clinical considerations (e.g. molecular test for tuberculous meningitis; cryptococcal antigen test for cryptococcal meningitis).

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Diagnosis of acute bacterial meningitis

Overview

Blood testing
Obtain blood cultures (at least one set with one aerobic bottle and one anaerobic bottle) as soon as possible, preferably before antibiotic therapy.
Perform a parasitological test for malaria (microscopy or RDT) in malaria-endemic areas.
Test for HIV and measure glucose; where resources allow, obtain a complete blood count, C-reactive protein and procalcitonin.
Consider additional tests based on clinical assessment and available resources, including electrolytes, kidney and liver function tests, coagulation studies, lactate, disease-specific serology (e.g. arboviral diseases, neurosyphilis, Lyme disease, leptospirosis, brucellosis, rickettsioses), and molecular tests.
Consider cryptococcal meningitis in people living with HIV or a predisposing immunocompromised state and perform a serum, plasma or whole-blood CrAg assay in individuals where lumbar puncture is not performed.
Lumbar puncture and CSF testing
Perform a lumbar puncture as soon as possible, preferably before antibiotic therapy, unless there are absolute or relative contraindications.
Do not delay treatment if there is a delay in lumbar puncture or while awaiting cranial imaging.
Do not perform a lumbar puncture in people with absolute contraindications (i.e. ongoing haemodynamic or respiratory compromise, a severe bleeding disorder, a skin or soft tissue infection or a spinal epidural abscess close to puncture site).
Defer lumbar puncture in people with relative contraindications (GCS < 10, focal neurological signs, cranial nerve deficits, papilloedema, new-onset seizures in adults, or severe immunocompromised state) and reassess lumbar puncture indication after cranial imaging or if these features resolve (in the absence of cranial imaging).
Send collected samples for culture and molecular tests for bacterial and viral pathogens, Gram stain, total and differential white blood cell count, red blood cell count, total protein, glucose; consider lactate prior to antibiotic therapy and if resources allow.
Consider tuberculous meningitis in people at high risk (e.g. unvaccinated children <5 years in high burden settings; people living with HIV) and send collected samples for NAAT, culture and direct microscopy.
Consider cryptococcal meningitis in people living with HIV or a predisposing immunocompromised state and test for CSF CrAg.
Cranial imaging
Do not perform cranial imaging routinely.
If readily accessible, perform cranial imaging in people presenting with GCS < 10, focal neurological signs, cranial nerve deficits, papilloedema, new-onset seizures (in adults) or severe immunocompromised state.
If cranial imaging detects space-occupying lesions with midline shift, severe or diffuse cerebral oedema or obstructive hydrocephalus, do not perfom a lumbar puncture due to the higher risk of brain herniation.

CBC: complete blood count. CrAg: cryptococcal antigen. CSF: cerebrospinal fluid. GCS: Glasgow Coma Scale. NAAT: nucleic acid amplification test. RDT: rapid diagnostic test.

Diagnosis of acute bacterial meningitis

Blood testing

Core investigations	Purpose of the test
Culture and AST	To identify the causative bacterial pathogen, confirm diagnosis, detect antimicrobial resistance and enable targeted treatment
Malaria test (microscopy or RDT)	To diagnose cerebral malaria (a common cause of fever and impaired consciousness) in individuals residing in or travelling to endemic areas
HIV test	To diagnose HIV infection and ensure optimized care
Glucose	To calculate CSF-blood ratio and support the differential diagnosis (bacterial versus viral disease) To diagnose hypoglycemia (a life-threatening complication, especially in young children) To diagnose hyperglycemia (a particular concern of individuals with diabetes mellitus and a common complication of corticosteroid treatment)
Complete blood count	To support the differential diagnosis (bacterial versus non-bacterial disease)[a] and ensure optimized supportive care (e.g. management of severe anemia)
C-reactive protein	To support the differential diagnosis (inflammatory versus non-inflammatory disorder; bacterial versus non-bacterial disease)[a]
Procalcitonin	To support the differential diagnosis (bacterial versus non-bacterial disease)[a]
Additional investigations	
Electrolytes	To diagnose and manage electrolyte abnormalities, including sodium disturbances (e.g. hyponatremia may indicate SIADH)
Kidney and liver function tests	To detect organ dysfunction and ensure optimized care, including in individuals presenting with sepsis or septic shock
Coagulation studies	To detect coagulation abnormalities and screen for disseminated intravascular coagulation (a life-threatening complication of sepsis or septic shock)
Lactate	To diagnose lactic acidosis and guide management in critically ill individuals
Disease-specific serology	To support the diagnosis of viral and bacterial infections (e.g. arboviral diseases, neurosyphilis, Lyme disease, leptospirosis, brucellosis, rickettsioses) in selected cases
CrAg	To support the diagnosis of cryptococcal meningitis in individuals at risk where lumbar puncture is not performed
Molecular tests	To potentially identify the causative pathogen and confirm diagnosis

AST: antimicrobial susceptibility testing. CrAg: cryptococcal antigen. CSF: cerebrospinal fluid. RDT: rapid diagnostic test. SIADH: syndrome of inappropriate antidiuretic hormone secretion.
[a] This test cannot be used alone to diagnose or rule out bacterial meningitis.

Diagnosis of acute bacterial meningitis

Lumbar puncture

In whom?

Perform lumbar puncture in all children and adults with suspected acute bacterial meningitis in the absence of absolute or relative contraindications.

Absolute contraindications to lumbar puncture

- Ongoing haemodynamic compromise (until stabilized)
- Ongoing respiratory failure (until stabilized)
- Severe bleeding disorder
- Skin or soft tissue infection overlying or close to puncture site
- Epidural abscess close to puncture site

Relative contraindications to lumbar puncture

- Glasgow Coma Scale score < 10
- Focal neurological signs or cranial nerve deficits
- Papilloedema
- New-onset seizures (in adults)
- Severe immunocompromised state

When?

Perform lumbar puncture as soon as possible, ideally before initiation of antibiotic therapy.

Do not delay treatment initiation if there is any delay in lumbar puncture or while awaiting cranial imaging.

What

Observe macroscopic appearance and determine opening pressure (where possible)

Perform culture and antimicrobial susceptibility testing

Perform molecular tests (PCR)

Perform Gram stain

Obtain total and differential white blood cell count

Obtain red blood cell count

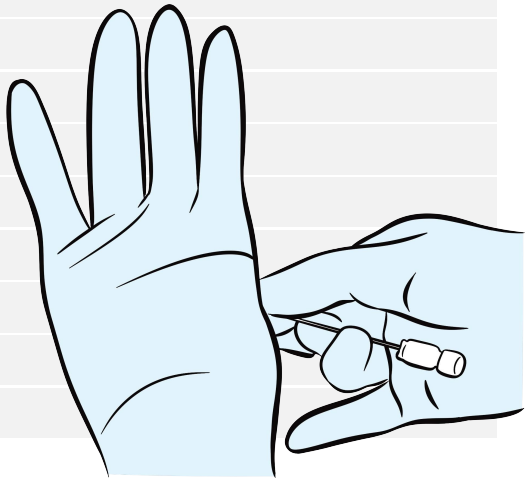
Determine total protein concentration

Determine glucose concentration

Consider measuring lactate levels (prior to antibiotic therapy and if resources allow)

Perform bacterial antigen detection tests (for outbreak detection and response)

Consider additional testing for tuberculous and/or cryptococcal meningitis (in individuals at risk)



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Diagnosis of acute bacterial meningitis

Lumbar puncture

Good clinical practice	
Perform lumbar puncture in all children and adults with suspected acute bacterial meningitis in the absence of absolute or relative contraindications.	
Perform lumbar puncture as soon as possible, ideally before initiation of antibiotic therapy.	
How to perform a lumbar puncture: step-by-step	
1	Explain the procedure to the person (or the caregiver), answer any questions and obtain consent.
2	Position the person in the sitting position or lying on their side.
3	Label the collection tubes with relevant ID information and date and time of collection.
4	Wear a surgical mask, wash your hands and put on sterile gloves.
5	Ensure that the person is comfortable and unlikely to move during the procedure.
6	Clean the skin overlying the lumbar spine with povidone-iodine or chlorhexidine (0.5% in 70% alcohol) and allow it to dry completely.
7	Identify the right and left posterior superior iliac crests by palpation, then trace the fingers medially toward the spinal midline.
8	Locate the puncture site at the midline, between L4 and L5 or L3 and L4 intervertebral spaces.
9	Consider infiltrating the skin and subcutaneous tissue with local anesthetic (e.g. 1% lidocaine) based on available resources.
10	Insert the needle[a] into the skin between the two vertebral spines with the bevel facing up.
11	Advance the needle incrementally, periodically remove the stylet to check for CSF flow and reinsert the stylet for each advancement.
12	If the person is lying on their side, consider attaching the manometer to the hub of the needle with a 3-way stopcock and recording the peak value of CSF opening pressure.
13	Remove a total of approximately 3 to 5 mL of CSF (if possible) into collection tubes.
14	Slowly withdraw the needle.
15	Cover the insertion site with adhesive dressing and instruct the person to lie flat for approximately 30 minutes.
16	Discard the needle in a puncture-resistant, autoclavable container.

CSF: cerebrospinal fluid. ID: identification.

[a] Atraumatic needles should be preferred to cutting needles when they are available, provided that adequate expertise in their use is available.

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Diagnosis of acute bacterial meningitis

Cerebrospinal fluid testing

Core investigations	WHO recommendation	Purpose of the test
Culture and AST	Recommended (reference standard)	To identify bacterial and fungal pathogens, confirm diagnosis, detect antimicrobial resistance and enable targeted treatment
Molecular tests (singleplex or multiplex PCR)	Recommended (in addition to culture)	To identify the causative pathogen and confirm diagnosis
Gram stain	Recommended	To diagnose bacterial meningitis and assess bacterial morphology
White blood cell total count	Recommended	To support the differential diagnosis
White blood cell differential count	Recommended	To support the differential diagnosis
Red blood cell count	Recommended	To detect traumatic lumbar puncture or cerebral haemorrhage
Total protein	Recommended	To support the differential diagnosis
Glucose	Recommended	To support the differential diagnosis
Lactate	Suggested prior to antibiotics and if resources allow	To support the differential diagnosis
Bacterial antigen detection tests[a]	Recommended for surveillance purposes	To support outbreak detection and response
Additional investigations		
NAAT for *Mycobacterium tuberculosis*[b]	Recommended in people with suspected tuberculous meningitis	To diagnose tuberculous meningitis and detect rifampicin resistance
CrAg	Recommended in people with suspected cryptococcal meningitis	To diagnose cryptococcal meningitis

AST: antimicrobial susceptibility testing. CrAg: cryptococcal antigen. CSF: cerebrospinal fluid. NAAT: nucleic acid amplification test. PCR: polymerase chain reaction.
[a] Bacterial antigen detection tests include latex agglutination tests and lateral flow assays.
[b] Where possible, culture may be performed in addition to NAAT testing to maximize the opportunity for diagnosis and detection of drug-resistant strains.

Diagnosis of acute bacterial meningitis

Cerebrospinal fluid sample storage and transportation

In resource-limited settings
Use dry tubes, cryotubes and T-I vials to transport CSF samples to reference laboratories for further testing based on a context-appropriate laboratory testing strategy.
Dry tubes
Use dry tubes to conduct the following CSF investigations: Gram stain, WBC count (total and differential), RBC count, total protein, glucose, lactate and bacterial antigen detection tests.
Store samples at room temperature.
Transport samples in triple packaging.
Cryotubes
Use cryotubes for CSF molecular testing (PCR).
Store samples at refrigerator temperature (4 °C) or frozen (-20 °C).
Transport samples in cold chain and triple packaging.
Trans-isolate (T-I) vials
Use T-I vials to obtain CSF culture.
Remove a vial of T-I medium from the refrigerator at least 30 minutes before inoculation with the CSF sample.
Check if there is any visible growth or turbidity. If there is visible growth or turbidity, discard the vial, as it may be contaminated.
Lift the small central lid of the metal cap on top of the T-I vial.
Disinfect the top of the T-I vial with alcohol and allow it to dry completely.
Using a new, sterile needle and syringe, inoculate 0.5-1.0 mL of a CSF sample into the T-I vial.
If the sample is not expected to be transported within 24 hours, puncture the top of the T-I vial with a sterile needle to ventilate and ensure bacteria growth.
Keep the sample at room temperature and away from light and cold.
Label the T-I vial and complete the appropriate form.
Remove the needle before placing the vial in triple packaging for transport to the laboratory.
CSF: cerebrospinal fluid. PCR: polymerase chain reaction. RBC: red blood cell. T-I: trans-isolate. WBC: white blood cell.

Diagnosis of acute bacterial meningitis

Interpretation of initial cerebrospinal fluid findings

Macroscopic appearance, cellularity, glucose and total protein

Perform all these CSF investigations in suspected cases of acute bacterial meningitis, as the combination of results can provide diagnostic clues and orientate clinical decision-making.[a,b]

Cloudy, turbid or purulent appearance High to very high WBC count (>100-10.000/mm^3 or >100-10.000/µL) Neutrophil predominance Low CSF-blood glucose ratio (<0.4) Low glucose (<40 mg/dL or <2.2 mmol/L) High total protein (>45 mg/dL or > 0.45 g/L)	Clear appearance High WBC count (10-500/mm^3 or 10-500/µL) Lymphocyte predominance Normal CSF-blood glucose ratio (0.4-0.7) Normal glucose (40-70 mg/dL; 2.2-3.9 mmol/L) Normal to high total protein (>15 mg/dL or > 0.15 g/L)	Clear appearance High WBC count (10-500/mm^3 or 10-500/µL) Lymphocyte predominance Low CSF-blood glucose ratio (<0.4) Low glucose (<40 mg/dL or <2.2 mmol/L) High total protein (>45 mg/dL or > 0.45 g/L)	Clear appearance Normal WBC count (<5/mm^3 or <5/µL) Normal CSF-blood glucose ratio (0.4-0-7) Normal glucose (40-70 mg/dL; 2.2-3.9 mmol/L) Normal total protein (15-45 mg/dL or 0.15-0.45 g/L)
Consider bacterial meningitis the most likely diagnosis[c]	Consider viral meningitis (most likely if no prior antibiotic treatment) and partially treated bacterial meningitis[d]	Consider partially treated bacterial meningitis, tuberculous meningitis and cryptococcal meningitis[e]	Consider meningitis unlikely
Continue IV empiric antibiotic therapy	Continue IV empiric antibiotic therapy	Add appropriate CSF tests if not ongoing Continue IV empiric antibiotic therapy Consider need for empiric treatment for tuberculous or cryptococcal meningitis	Consider alternative diagnoses Evaluate on a case-by-case basis

CSF: cerebrospinal fluid. WBC: white blood cells.

[a] The diagnostic yield of CSF tests can be reduced by prior initiation of antibiotic therapy. CSF changes can also be attenuated and should be interpreted with caution in people living with HIV and older individuals.

[b] CSF glucose levels should always be compared to blood glucose levels. When this is not possible, CSF glucose range values are based on presumed blood glucose of 100 mg/dL or 5.6 mmol/L.

[c] In the absence of prior antibiotic therapy, a CSF lactate concentration >3.5 mmol/L is consistent with bacterial meningitis.

[d] Most or all of these CSF findings are also consistent with some non-pyogenic bacterial infections, including neurosyphilis, Lyme disease, leptospirosis and rickettsioses

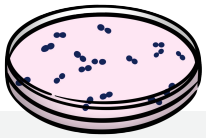
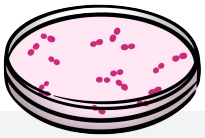
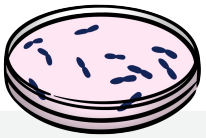
[e] Most or all of these CSF findings are also consistent with neurobrucellosis and several non-infectious disorders, which, however, more commonly present with a subacute or chronic course.

World Health Organization

Diagnosis of acute bacterial meningitis

Interpretation of cerebrospinal fluid Gram stain

- Perform Gram stain on CSF samples of suspected cases of acute bacterial meningitis, as it has the advantage of suggesting the bacterial etiology before culture results.
- Consider that the diagnostic yield of CSF Gram stain can be reduced and should be interpreted with caution after initiation of antibiotic therapy.[a]

			
Gram-positive diplococci	Gram-negative diplococci	Gram-positive bacilli or coccobacilli	Gram-negative coccobacilli
Streptococcus pneumoniae is the most likely pathogen.	*Neisseria meningitidis* is the most likely pathogen.	*Listeria monocytogenes* is the most likely pathogen.	*Haemophilus influenzae* is the most likely pathogen.
Continue IV ceftriaxone or cefotaxime ± IV vancomycin[b]	Continue IV ceftriaxone or cefotaxime	Continue or start IV ampicillin or amoxicillin	Continue IV ceftriaxone or cefotaxime

If the other CSF findings are consistent with bacterial meningitis but the Gram stain is negative, do not rule out bacterial meningitis and continue IV empiric antibiotic treatment as initially prescribed.

CSF: cerebrospinal fluid.

[a] The following flowchart applies to cases where antibiotic therapy is not yet initiated at the time of CSF collection and results are unequivocal.

[b] Vancomycin should be considered in addition to ceftriaxone or cefotaxime in areas with documented high baseline prevalence of *Streptococcus pneumoniae* resistant to penicillins or third-generation-cephalosporins at the national or sub-national level.

World Health Organization

Diagnosis of acute bacterial meningitis

Laboratory confirmation tests

General considerations
Definitive confirmation of the causative pathogen is based on culture or molecular tests performed on CSF or blood samples.
Results should be used to orientate clinical decision-making and inform the implementation of public health measures.
CSF culture
Perform CSF culture and AST in cases of suspected acute bacterial meningitis, as they are the gold standard for bacterial pathogen identification and essential in guiding antibiotic therapy.
Collect CSF samples as soon as possible because the diagnostic yield of culture decreases if the sample is collected after antimicrobial treatment has begun.
Use culture and AST results to tailor antibiotic therapy based on the identified pathogen and antibiotic susceptibility profiles.
CSF molecular tests
Perform CSF PCR (singleplex or multiplex) in cases of suspected acute bacterial meningitis (in addition to CSF culture).
Do not use CSF PCR to replace CSF culture, which remains the gold standard tests for bacterial pathogen identification and characterization of antibiotic susceptibility profiles.
Interpret CSF PCR results in the context of clinical presentation and additional laboratory findings.
Blood culture
Perform blood cultures and AST in cases of suspected acute bacterial meningitis, as bacteremia may often concur.
Collect blood samples as soon as possible because the diagnostic yield of culture decreases if the sample is collected after antimicrobial treatment has begun.
Use culture and AST results to tailor antibiotic therapy based on the identified pathogen and antibiotic susceptibility profiles.
Blood molecular tests
Where resources allow, consider blood molecular tests in cases of suspected acute bacterial meningitis (in addition to blood cultures).
Interpret blood molecular test results in the context of clinical presentation and additional laboratory findings.

AST: antimicrobial susceptibility testing. CSF: cerebrospinal fluid. PCR: polymerase chain reaction.

Treatment of acute bacterial meningitis

Overview

Antibiotic therapy
Treat for bacterial meningitis all suspected cases until the diagnosis has been excluded.
Start IV empiric antibiotic therapy as soon as possible and within 1 hour of admission to an appropriate health-care facility.[a]
Outside epidemics, choose the empiric antibiotic regimen based on the most likely pathogen. • Administer IV ceftriaxone or cefotaxime. • Add IV ampicillin or amoxicillin in people presenting with ≥1 risk factor for *Listeria monocytogenes* infection: age >60 years, pregnancy or immunocompromised state. • Consider adding IV vancomycin in areas with documented high baseline prevalence of *Streptococcus pneumoniae* resistant to penicillins or third-generation-cephalosporins at the national or sub-national level.
During meningococcal disease epidemics, administer parenteral ceftriaxone as empiric monotherapy.
Review antibiotic therapy and select the narrowest spectrum antibiotic appropriate as soon as the causative pathogen is isolated and antibiotic susceptibility testing results are known.
Tailor antibiotic therapy duration based on the identified pathogen and the clinical response.
Adjunctive corticosteroids
Outside epidemics, start IV corticosteroids (dexamethasone) with the first dose of antibiotics.
During meningococcal disease epidemics, do not routinely administer IV corticosteroids as adjunctive treatment.
During pneumococcal disease epidemics, start IV corticosteroids (dexamethasone) with the first dose of antibiotics.
Review, adjust or discontinue IV corticosteroids (dexamethasone) based on initial cerebrospinal fluid findings and the identified pathogen.
Supportive care
Ensure adequate oxygenation, ventilation and circulation, and secure IV access.
Manage acute complications as appropriate (e.g. increased intracranial pressure, septic shock, disseminated intravascular coagulation, recurrent seizures or status epilepticus).
Assess for neuropsychological sequelae (e.g. hearing loss) early and ensure prompt referral to appropriate rehabilitation and specialized services.

AST: antimicrobial susceptibility testing. IV: intravenous.
[a] Appropriate health-care facility: lumbar puncture can be performed when indicated and adequate monitoring and management of severe illness can be ensured.

Treatment of acute bacterial meningitis

Empiric antibiotic therapy outside epidemics

Adult or child with suspected acute bacterial meningitis admitted to an appropriate health-care facility[a] outside epidemic settings

Start IV empiric antibiotic therapy as soon as possible and within 1 hour of admission
Do not delay treatment in case of any delay in diagnostic investigations

Start IV ceftriaxone or cefotaxime[b]

≥1 risk factor for listeriosis (age >60, pregnancy, immunocompromised state)

Add IV ampicillin or amoxicillin[b]

High rates of penicillin or 3rd-generation cephalosporin resistant *S. pneumoniae*

Add IV vancomycin[b,c]

Review and optimize antibiotic therapy as soon as the causative pathogen is isolated and antimicrobial susceptibility testing results are known

Risk factors for listeriosis

- Age >60 years
- Pregnancy
- Advanced HIV disease
- Alcohol use disease
- Diabetes mellitus
- End-stage kidney disease
- Immunosuppressive therapy
- Liver cirrhosis
- Malignancy
- Organ transplantation

Penicillin or third-generation cephalosporin resistance

Prevalence thresholds to define settings at risk for penicillin or third-generation cephalosporin resistance of *S. pneumoniae* should be defined at the national or sub-national level.

Beta-lactam allergy

- In most cases of non-severe penicillin allergy, cephalosporins can be safely used, and vice versa.
- In cases of previous life-threatening reaction upon exposure to beta-lactams, any use of beta-lactams should be avoided.
- If signs or symptoms of a clinically significant hypersensitivity reaction or anaphylaxis occur, the antibiotic infusion should be immediately discontinued and appropriate medications, supportive therapy and airway management should be initiated.

IV: intravenous.

[a] Appropriate health-care facility: lumbar puncture can be performed when indicated and adequate monitoring and management of severe illness can be ensured.

[b] For antibiotic dosages, please refer to the section Intravenous antibiotic dosing.

[c] In areas with low tuberculosis burden, rifampicin can be used as an alternative to vancomycin. In areas with high tuberculosis burden, rifampicin can be used only when vancomycin is not readily available or contraindicated.

Treatment of acute bacterial meningitis

Empiric antibiotic therapy during meningococcal disease epidemics

Adult or child with suspected or probable acute bacterial meningitis
during a confirmed meningococcal disease epidemic

Start IV ceftriaxone as soon as possible (2 g every 12 hours in adults; 50 mg/kg every 12 hours in children)[a,b]
Do not delay treatment in case of any delay in diagnostic investigations

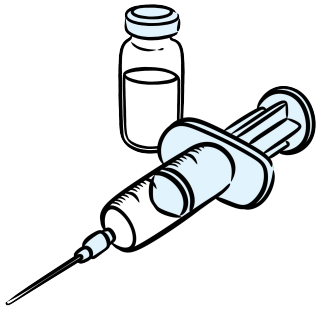
Is the causative pathogen isolated?

Yes

Review antibiotic therapy and select the narrowest spectrum antibiotic appropriate

No

Continue ceftriaxone for a total duration of 5 days[c]



When inpatient completion of antibiotic therapy is not feasible

Consider discharging the person and giving parenteral ceftriaxone at full dose once daily (up to 4 g in adults; 100 mg/kg in children) in an outpatient setting if:

- The person is clinically stable, and
- The person can return to the health-care facility every day until treatment completion.

When a 5-day antibiotic regimen is not feasible

Consider single-dose ceftriaxone protocols in adults and children (except infants), provided that:

- The epidemic is confirmed to be caused by *Neisseria meningitidis*, and
- The person can be reviewed after 24 and 48 hours.

If there is no clinical recovery, hospitalize the person, extend empiric treatment and ensure appropriate management.

IV: intravenous.

[a] If IV administration is not immediately feasible, IM ceftriaxone should be given.

[b] Empiric treatment regimens may be adjusted according to national guidance based on *N. meningitidis* susceptibility profiles detected during the outbreak.

[c] When ceftriaxone is not available and a longer treatment course is considered impractical or not feasible, one or two intramuscular injections of long-acting chloramphenicol might be used for cases aged over 2 years (where available).

Treatment of acute bacterial meningitis

Empiric antibiotic therapy during pneumococcal disease epidemics

Adult or child with suspected or probable acute bacterial meningitis during a confirmed pneumococcal disease epidemic

Start IV ceftriaxone as soon as possible (2 g every 12 hours in adults; 50 mg/kg every 12 hours in children)[a,b]

Is there a documented high prevalence of *S. pneumoniae* resistant to penicillins or 3rd-generation-cephalosporins locally?

Yes

Start IV vancomycin in combination with ceftriaxone

No

Administer ceftriaxone monotherapy

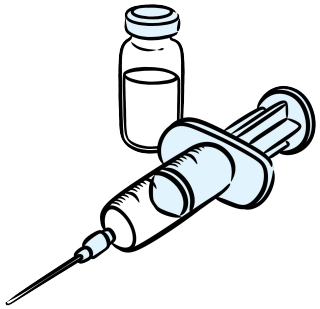
Is the causative pathogen isolated?

Yes

Review antibiotic therapy and select the narrowest spectrum antibiotic appropriate

No

Continue antibiotic therapy for a total duration of 10 days



IV: intravenous.

[a] If IV administration is not immediately feasible, IM ceftriaxone should be given.

[b] Empiric treatment regimens may be adjusted according to national guidance based on *S. pneumoniae* susceptibility profiles detected during the outbreak.

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Treatment of acute bacterial meningitis

Specific antibiotic therapy (during and outside epidemics)

Good clinical practice		
Review and optimize antibiotic therapy as soon as the causative pathogen is isolated and antimicrobial susceptibility testing results are known.		
Pathogen[a]	Specific antibiotic therapy (IV)	Total duration
Streptococcus pneumoniae Penicillin-susceptible Penicillin-resistant Cephalosporin-resistant	Penicillin G (Benzylpenicillin) / Ampicillin / Amoxicillin Ceftriaxone / Cefotaxime Vancomycin + Ceftriaxone / Cefotaxime *or* Vancomycin + Levofloxacin / Moxifloxacin[b] or Vancomycin + Rifampicin[c] *or* Rifampicin[c] + Ceftriaxone / Cefotaxime	10-14 days
Neisseria meningitidis Penicillin-susceptible Penicillin-resistant	Penicillin G (Benzylpenicillin) / Ampicillin / Amoxicillin Ceftriaxone / Cefotaxime	5-7 days
Listeria monocytogenes	Penicillin G (Benzylpenicillin) / Ampicillin / Amoxicillin	21 days
Streptococcus agalactiae	Penicillin G (Benzylpenicillin) / Ampicillin / Amoxicillin	14-21 days
Haemophilus influenzae Beta-lactamase-negative Beta-lactamase-positive	Ampicillin / Amoxicillin Ceftriaxone / Cefotaxime	7-10 days
Viruses	Discontinue empiric antibiotic therapy	-
Unknown	Continue empiric antibiotic therapy	7 days (outside epidemics) 5 days (during meningococcal disease epidemics) 10 days (during pneumococcal disease epidemics)
Decisions on treatment discontinuation should also be guided by clinical recovery, defined as the resolution of fever, vital sign abnormalities and altered consciousness for ≥48 hours.		

[a] For treatment of tuberculous and cryptococcal meningitis, please refer to the latest WHO guidelines (Bibliography).
[b] Fluoroquinolone-containing regimens (i.e. regimens with levofloxacin and moxifloxacin) should be considered as an option for adults with pneumococcal meningitis.
[c] Rifampicin-containing regimens should be avoided when tuberculosis is a concurrent concern.

Treatment of acute bacterial meningitis

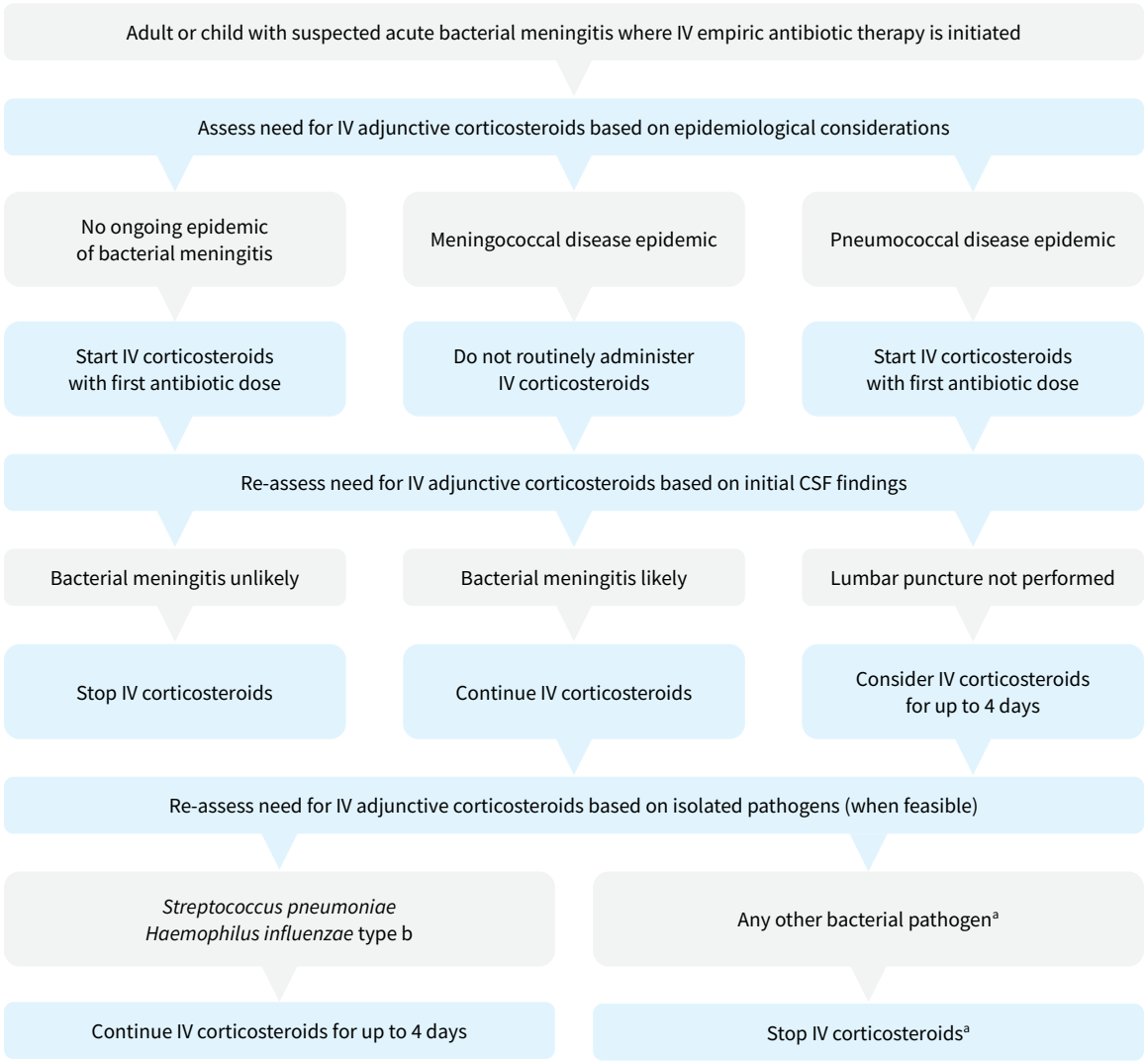
Intravenous antibiotic dosing

Antibiotic	IV dose in adults[a]	IV dose in children (>1 month)[a]	Maximum daily dose[a]	AWaRe group
Amoxicillin	2 g every 4 hours *or* 3 g every 6 hours	50 mg/kg every 4 hours (max 2 g every 4 hours) *or* 75 mg/kg every 6 hours (max 3 g every 6 hours)	12 g/day	Access
Ampicillin	2 g every 4 hours *or* 3 g every 6 hours	50 mg/kg every 4 hours (max 2 g every 4 hours) *or* 75 mg/kg every 6 hours (max 3 g every 6 hours)	12 g/day	Access
Cefotaxime	2 g every 4 hours *or* 3 g every 6 hours	50 mg/kg every 4 hours (max 2 g every 4 hours) *or* 75 mg/kg every 6 hours (max 3 g every 6 hours)	12 g/day	Watch
Ceftriaxone	2 g every 12 hours[b]	50 mg/kg every 12 hours (max 2 g every 12 hours)[b]	4 g/day	Watch
Chloramphenicol[c]	1 g every 6 hours[d]	25 mg/kg every 6 hours (max 1 g every 6 hours)[d]	4 g/day	Access
Levofloxacin	750 mg every 24 hours	-	750 mg/day	Watch
Moxifloxacin	400 mg every 24 hours	-	400 mg/day	Watch
Penicillin G (Benzylpenicillin)	4 million IU or 2.4 g every 4-6 hours	50 000 IU/kg or 30 mg/kg every 4 hours (max 4 million IU or 2.4 g/dose) *or* 100 000 IU/Kg or 60 mg/kg every 6 hours (max 4 million IU or 2.4 g/dose)	24 million IU or 14.4 g/day	Access
Rifampicin	300 mg every 12 hours *or* 600 mg every 24 hours	10 mg/kg every 12 hours (max 300 mg every 12 hours)	-	Watch
Vancomycin[e]	15-20 mg/kg every 8-12 hours[f]	15-20 mg/kg every 6-8 hours[f]	4 g/day	Watch

[a] The doses presented in the table apply to individuals with normal renal and hepatic function. In the presence of renal impairment, dosing adjustments are required for amoxicillin, ampicillin, cefotaxime, levofloxacin, penicillin G, rifampicin (end-stage kidney disease) and vancomycin.
[b] In selected circumstances where twice daily administration cannot be operationalized, once daily administration is possible: 4 g every 24 hours in adults; 100 mg/kg (max 4 g) every 24 hours in children.
[c] Severe life-threatening blood dyscrasias (aplastic anemia, thrombocytopenia and granulocytopenia) are known to occur after the administration of chloramphenicol and their potential occurrence should be carefully monitored. Initial doses may be reduced after clinical improvement.
[d] During meningococcal disease epidemics, in cases where ceftriaxone is not available and a longer treatment course is considered impractical or not feasible, intramuscular long-acting chloramphenicol might be used for cases aged over 2 years (single-dose 100 mg/kg [max 3 g], potentially followed by a second dose after 24 hours if there is no clinical improvement).
[e] The risk of toxicity, including acute kidney injury, increases as a function of trough vancomycin concentration, especially when trough is consistently above 15 to 20 mg/L. Therefore, where feasible, trough vancomycin concentration should be regularly monitored and dose adjusted accordingly.
[f] When monitoring of trough vancomycin concentration is not feasible, a total of 3 g per day should not be exceeded in adults and 750 mg per dose should not be exceeded in children.

Treatment of acute bacterial meningitis

Adjunctive corticosteroid therapy



Practical information on corticosteroid administration

- When recommended, administer corticosteroids intravenously.
- When recommended, administer corticosteroids with the first dose of antibiotics or as soon as possible after the first dose and no later than 12 hours.
- When recommended, continue corticosteroids for a total of up to 4 days or until discontinuation is indicated.
- Use dexamethasone (10 mg every 6 hours in adults; 0.15 mg/kg [max 10 mg] every 6 hours in children).
- When dexamethasone cannot be administered, consider hydrocortisone or methylprednisolone at equivalent doses.

Contraindications to corticosteroids

- Cerebral malaria
- Cryptococcal meningitis (suspected or confirmed)
- Known hypersensitivity to dexamethasone or any component of the formulation

People living with HIV

- Do not administer adjunctive corticosteroids in people living with HIV where cryptococcal meningitis is suspected or cannot be ruled out.
- Do not administer adjunctive corticosteroids for suspected acute bacterial meningitis in people with advanced HIV disease.
- Consider adjunctive corticosteroids for suspected acute bacterial meningitis in people living with HIV who are on antiretroviral therapy and have undetectable viral load (less than 50 copies/µL).

CSF: cerebrospinal fluid. IV: intravenous.

[a] If *Mycobacterium tuberculosis* is isolated, corticosteroid doses should be adjusted and tapered over 6-8 weeks.

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Treatment of acute bacterial meningitis

Supportive care

Maintenance fluids
Do not routinely restrict fluid intake.[a]
Administer maintenance fluids orally or by enteric tube (e.g. nasogastric tube).
When fluids cannot be administered orally or by enteric tube, use isotonic solutions (e.g. Ringer's lactate, normal saline).
Do not routinely use hypotonic fluids (e.g. one-half or one-quarter normal saline) as they may contribute to hyponatremia and potentially exacerbate cerebral oedema.
Do not routinely use glucose-based solutions unless hypoglycemia is a concurrent concern (e.g. young children).
Increased intracranial pressure
Manage increased ICP as a potentially life-threatening condition that requires early detection and immediate interventions.
Suspect increased ICP based on a combination of symptoms (e.g. severe headache, vomiting) and signs (e.g. impaired consciousness, cranial nerve deficit, papilloedema, and a triad of bradycardia, hypertension and respiratory depression, known as Cushing reflex).
Rapidly assess and manage the person with suspected increased ICP: • Stabilize the person (ABCDE). • Elevate the head of the bed by 15-30°. • Keep normal body temperature (e.g. antipyretics or cooling blankets for high body temperature). • Consider IV mannitol or hypertonic saline. • Hyperventilate if person is mechanically ventilated (target pCO_2: 26 to 30 mmHg).
In people with cryptococcal meningitis, repeat daily lumbar puncture(s) to reduce the CSF pressure to <20 cm H_2O or halve the baseline pressure until manifestations resolve and for ≥2 days.[b]
Chronic complications and sequelae
Major sequelae include hearing loss, focal neurological deficits, neuropsychological impairment (cognitive impairment in adults, intellectual disability and/or behavioural changes in children), hydrocephalus, seizure recurrence and epilepsy, limb or digit amputation, and skin scarring.
Assess for sequelae before discharge and at follow-up (within 4 weeks) and perform audiological screening before or within 4 weeks of discharge.
Provide early rehabilitation for people with sequelae and consider cochlear implant for people with sensorineural hearing loss.
Offer psychological support to the affected person and the caregivers.

ABCDE: Airway, Breathing, Circulation, Disability and Exposure. CSF: cerebrospinal fluid. ICP: intracranial pressure. IV: intravenous.

[a] Consider moderate fluid restriction in people without hypovolemia presenting with serum sodium levels <130 mEq/L (suspected syndrome of inappropriate antidiuretic hormone secretion [SIADH]).

[b] Consider lumbar or ventricular shunts only if the person is on appropriate antifungal therapy and if therapeutic lumbar punctures have failed to control ICP.

Treatment of acute bacterial meningitis

Pre-referral treatment

General considerations

Ensure that any individual with suspected acute meningitis is managed in an appropriate health-care facility.[a]

If the person is not initially admitted to an appropriate health-care facility, organize a safe referral or transfer as soon as possible.

Antibiotic therapy

Administer pre-referral antibiotic therapy when acute bacterial meningitis is strongly suspected and a clinically significant delay in transfer is expected (>30 minutes from door to door).

- Administer parenteral ceftriaxone.[b]
- When no meningococcal or pneumococcal disease outbreak is ongoing, consider adding parenteral ampicillin[b] in people presenting with ≥1 risk factor for *Listeria monocytogenes* infection (i.e. age >60 years, pregnancy or immunocompromised state).
- When no meningococcal disease outbreak is ongoing, consider adding IV vancomycin in the presence of a high baseline prevalence of *Streptococcus pneumoniae* resistant to penicillins or third-generation-cephalosporins at the national or sub-national level.

Do not administer pre-referral antibiotic therapy indiscriminately or when transfer can be swiftly ensured without a clinically significant delay (<30 minutes from door to door).

Adjunctive corticosteroids

Consider pre-referral adjunctive corticosteroids (dexamethasone) when all of the following conditions apply:

- Pre-referral antibiotic therapy is administered (i.e. acute bacterial meningitis is strongly suspected and a clinically significant delay in transfer is expected);
- Cerebral malaria is excluded;
- Cryptococcal meningitis is not a likely diagnosis (e.g. the person is not known or suspected to have advanced HIV disease);
- There is no ongoing meningococcal disease outbreak.

Supportive care

Ensure adequate oxygenation, ventilation and circulation, and start managing acute illness (as feasible).

Ensure appropriate fluid management.

- Use Ringer's lactate or normal saline for IV fluid resuscitation.
- Do not use glucose-based solutions unless hypoglycaemia is also a concern.
- Avoid overhydration and fluid restriction.

IM: intramuscular. IV: intravenous.

[a] Appropriate health-care facility: lumbar puncture can be performed when indicated and adequate monitoring and management of severe illness can be ensured.

[b] Prefer IV administration; if IV administration is not possible and/or an IV line is not secured, proceed with IM administration.

Prevention of secondary cases of meningococcal disease

Post-exposure antibiotic prophylaxis

Close contact of a meningococcal disease index case[a] (within 10 days of exposure)

- Known antimicrobial susceptibility profiles in index case
- Known antimicrobial susceptibility profiles in the community but not in index case
- Unknown antimicrobial susceptibility profiles in index case or the community

Administer antibiotic prophylaxis as soon as possible based on antimicrobial susceptibility profiles

Consider antibiotic prophylaxis

Choose between single-dose ciprofloxacin PO or ceftriaxone IM[b]
Consider 2-day rifampicin PO if ciprofloxacin or ceftriaxone cannot be used

Educate about clinical manifestations and ensure follow-up for at least 10 days following exposure
Notify local public health authorities

Antibiotic	Route	Duration	Adults	Children	AWaRe group
Ciprofloxacin	PO	Single dose	500 mg	20 mg/kg (max 500 mg)	Watch
Ceftriaxone	IM	Single dose	250 mg	125 mg	Watch
Rifampicin	PO	Two days	600 mg every 12 hours	10 mg/kg (max 600 mg) every 12 hours	Watch

Close contact

A close contact should be defined based on context-specific considerations and available resources and may include:

- Individuals with prolonged (>8 hours) exposure while in close proximity (<1 m) to the index case (e.g. household contacts);
- Individuals directly exposed to oral secretions of the index case (e.g. via kissing, mouth-to-mouth resuscitation).

From 7 days before symptom onset in the index case to 24 hours after initiation of appropriate antibiotic therapy.

Risk of antimicrobial resistance

- Antibiotic selection should be guided by AST results from index cases or AMR data within the community.
- Inappropriate use of antibiotic prophylaxis is associated with AMR selection pressure in nasopharyngeal *N. meningitidis*, gastrointestinal and genitourinary microbiota, and invasive bacterial pathogens (e.g. *Salmonella* Typhi).
- The increasing incidence of ciprofloxacin-resistant meningococcal strains worldwide raises concerns about potential failure.

Implementation considerations during large-scale epidemics

- Post-exposure antibiotic prophylaxis should be carefully integrated with the primary outbreak response measures.
- Reactive vaccination campaigns should not be delayed or replaced by post-exposure antibiotic prophylaxis.
- Access to antibiotics may be limited, and their use should be prioritized for clinical management of affected individuals.

IM: intramuscular. PO: oral. AMR: antimicrobial resistance. AST: antibiotic susceptibility testing.
[a] An index case is usually defined as a confirmed case of meningococcal disease.
[b] During pregnancy, ciprofloxacin should be avoided, and ceftriaxone is the preferred agent.

World Health Organization

Prevention of secondary cases of meningococcal disease

Infection prevention and control measures in health-care settings

Standard precautions
Implement standard precautions for all patients at all times.
Ensure appropriate hand hygiene, respiratory hygiene and cough etiquette, patient placement and use of personal protective equipment.
Ensure aseptic technique, safe injections and sharps injury prevention.
Ensure adequate environmental cleaning and appropriate handling of laundry and linen.
Ensure appropriate waste management, decontamination and reprocessing of reusable items and equipment.
Droplet precautions
Implement droplet precautions for all individuals with suspected acute bacterial meningitis or invasive meningococcal disease until meningococcal infection has been excluded or the individual has received at least 24 hours of effective antibiotic therapy.
Put on a medical mask before entering the patient room and remove it upon exit.
Perform hand hygiene before and after the use of masks.
Wear additional personal protective equipment if indicated (e.g. eye protection), based on a risk assessment.
Place the patient in a single room.
Consider the following when single-patient rooms are not available: • Prioritize any single-patient rooms for individuals with excessive cough and sputum production (if any). • Cohort patients with the same clinical manifestations, suspect diagnosis and confirmed diagnosis. • Physically separate patients by at least 1 meter and draw privacy curtains.
Use disposable or dedicated patient-care equipment (e.g. stethoscopes), and clean and disinfect equipment before use on other patients.
Instruct the patient to wear a mask and follow respiratory hygiene and cough etiquette when transport is necessary.

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Notes

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