

Diagnosis

When to do a lumbar puncture

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If you suspect meningitis, unless there is a specific contraindication

Lumbar puncture has long been a key investigation. The “classical signs” of meningitis are often absent in infants in the first year of life. Lumbar puncture is thus advocated for any infant who is drowsy or ill, without awaiting the development of meningeal signs.¹ Concerns about the perceived dangers of lumbar puncture² and a suggestion that it has little diagnostic value in meningococcal disease³ have led to fewer lumbar punctures being performed.⁴ Some experts have expressed concerns that not enough lumbar punctures are being performed, since the consequences of missing meningitis may be disastrous.⁵ A review of the indications for lumbar puncture is thus timely, and papers in this issue by McMaster and colleagues⁶ and Carroll and Brookfield⁷ contribute to this debate.

CRITICAL QUESTIONS

Critical questions include:

- What are the benefits of lumbar puncture in suspected meningitis?
- What are the contraindications to lumbar puncture?
- How is meningitis diagnosed and treated if an early lumbar puncture is not done?
- Should lumbar puncture be performed after a febrile convulsion?

WHAT ARE THE BENEFITS OF LUMBAR PUNCTURE IN SUSPECTED MENINGITIS?

In most cases lumbar puncture confirms or excludes bacterial meningitis. It is rare for microscopy of cerebrospinal fluid obtained at lumbar puncture to be normal, and a pathogen to be grown

later. This occurs most often in meningococcal meningitis (up to 8%).⁴ These children have clinical signs of meningitis or septicaemia (rash) and should receive antibiotics in spite of a “normal” cerebrospinal fluid. Children rarely develop meningitis some hours after a normal lumbar puncture. The suggestion that the lumbar puncture itself performed during bacteraemia may cause meningitis remains controversial and unproven.⁸

Initial Gram staining of cerebrospinal fluid reveals an organism in 68–80% of cases of meningitis,⁹ allowing appropriate choice of antibiotics. Subsequent culture gives information on antibiotic resistance, which is especially important in areas where antibiotic resistant pneumococci are prevalent.⁶

Obtaining cerebrospinal fluid also allows identification of uncommon pathogens, such as mycobacteria and fungi. This is particularly important in children with immunodeficiency or on an intensive care unit.

Enteroviral meningitis can be confidently diagnosed by cerebrospinal fluid polymerase chain reaction (PCR), which allows discontinuation of antibiotics and early discharge.¹⁰

WHAT ARE THE CONTRAINDICATIONS TO LUMBAR PUNCTURE?

Lumbar puncture should be deferred if there are signs of cerebral herniation, focal neurological signs, or cardiorespiratory compromise. Infection in the area the needle will traverse to get cerebrospinal fluid or signs of a bleeding disorder are also said to be contraindications,¹¹ but these are based on single case reports.¹²

Cerebral herniation

Symptoms and signs of cerebral herniation (table 1) occur in 4–6% of children with bacterial meningitis,^{13–15} and this complication accounts for 30% of deaths from bacterial meningitis.^{13 14} Cerebral herniation can occur when a lumbar puncture has not been done. However, case series have shown a temporal association between lumbar puncture and herniation.^{13–15} Thus delaying lumbar puncture when there are signs and symptoms of herniation may be lifesaving.

Computed tomography (CT) scanning is unhelpful in children with this clinical presentation; most children with bacterial meningitis and clinically suspected raised intracranial pressure have normal scans.¹⁶ Death from herniation following lumbar puncture can occur despite having a normal CT scan.^{15 17}

“A normal CT scan in a child with signs of cerebral herniation does not mean it is safe to do a lumbar puncture”

Disease mimicking meningitis

A few children with clinical signs of meningitis will have another condition (for example, tumour, abscess, or intracranial haemorrhage). Lumbar puncture in these situations would carry a high risk of herniation.¹⁸ The presence of focal signs, depressed consciousness, or failure to respond to treatment are thus an indication for an urgent CT scan to exclude these conditions.

Cardiorespiratory compromise

Excessive flexion of the trunk and neck during lumbar puncture may produce hypoxaemia in neonates,¹⁹ which can be prevented by preoxygenation.²⁰ Similar adverse effects may occur in children with meningococcal septic shock⁷; for this reason lumbar puncture should be deferred until the next day if a child is shocked.

HOW IS MENINGITIS DIAGNOSED IF AN EARLY LUMBAR PUNCTURE IS NOT DONE?

A delayed lumbar puncture can confirm the diagnosis of meningitis, since the cellular and biochemical changes remain in cerebrospinal fluid up to 44–68 hours after the start of antibiotic treatment.⁹ This information can guide subsequent treatment and is crucial when there is a differential diagnosis of cerebral malaria,

Table 1 Symptoms and signs of cerebral herniation

Glasgow coma score <8	
Abnormal pupil size and reaction	(unilateral or bilateral)
Absent doll's eye movements	
Abnormal tone	(decerebrate/decorticate posturing, flaccidity)
Tonic posturing	
Respiratory abnormalities	(hyperventilation, Cheyne–Stokes breathing, apnoea, respiratory arrest)
Papilloedema	(rare, especially in infants)

Abbreviations: CT, computed tomography; PCR, polymerase chain reaction

since this cannot be differentiated from meningitis clinically.²¹

Cerebrospinal fluid cultures are negative two hours after parenteral antibiotics are given in meningococcal meningitis, and negative six hours after parenteral antibiotics in pneumococcal meningitis (including antibiotic resistant strains).²²

"New molecular techniques for simultaneous detection of *Neisseria meningitidis*, *Streptococcus pneumoniae*, and *Haemophilus influenzae* by cerebrospinal fluid PCR may be helpful"²³

If lumbar puncture is not thought safe, empirical antibiotic therapy should be given without delay. In the UK at present a third generation cephalosporin alone is likely to be adequate, as cephalosporin resistant pneumococci are rare.²⁴ However, in countries where there is pneumococcal resistance to cephalosporins, vancomycin should be added.⁶ Increasing antibiotic resistance makes culturing the causative organism essential.

Blood culture and/or molecular diagnostic techniques may help identify the causative organism and their use should be considered in the following three settings.

Suspected childhood meningitis with non-blanching rash

Meningitis with a non-blanching rash is likely to be meningococcal. Many would suggest a lumbar puncture is unnecessary,^{3, 4, 25} but this clinical picture is not always a result of meningococcal disease. Of 63 children with meningism and a "meningococcal" rash, 51 had meningococcal disease, 10 had viral illnesses, and two had other types of bacterial meningitis (Riordan, unpublished data). Confirming the diagnosis of meningococcal disease is important now that group C conjugate meningococcal vaccine is given in the UK, to confirm the vaccine's efficacy and detect non-responders.²⁶

"Meningococcal PCR of cerebrospinal fluid obtained at a delayed lumbar puncture has a sensitivity of 81%"²⁸

Blood cultures are positive in 40–50% of cases of meningococcal septicaemia, but <10% if antibiotics are given.²⁷ PCR for meningococcal DNA is available in the UK.²⁸ The usefulness of blood PCR

for diagnosing meningococcal disease is not fully defined. In prospective studies sensitivity was only 47%,²⁹ but recently there have been suggestions that it has increased to 87% (Hackett *et al*, personal communication). The children in the study with negative blood PCR had a predominantly meningitic presentation.

Suspected childhood meningitis without a non-blanching rash

In the UK meningococcus is still the most likely organism to cause meningitis without rash, with pneumococcus the next most likely. Infection caused by *Haemophilus influenzae* is rare after Hib immunisation a decade ago. Pneumococcus or *Haemophilus* are grown from blood cultures in 80–90% of cases of meningitis caused by these organisms^{9, 30} if no prior antibiotics were given, but only 52–80% respectively after antibiotics.⁹ In meningococcal meningitis presenting without rash, blood cultures are positive in only 23% of children (Riordan, unpublished data), or less than 10% after antibiotics.²⁷ Meningococcal PCR of blood may be helpful (see above).

Neonatal meningitis

Blood cultures are positive in only 50% of neonates with meningitis.^{31, 32} Negative blood cultures thus cannot exclude meningitis in an ill neonate. Group B streptococci and coliforms commonly cause meningitis in neonates. Coliforms are often found in cerebrospinal fluid after 2–3 days of antibiotic treatment. However, group B streptococci clear from cerebrospinal fluid after eight hours of appropriate antibiotics.²² A delayed lumbar puncture in neonates may confirm a diagnosis of coliform meningitis and the need for prolonged antibiotic treatment.

SHOULD LUMBAR PUNCTURE BE PERFORMED AFTER A FEBRILE CONVULSION?

Carroll and Brookfield's review⁷ and another evidenced based review³³ suggest that the probability of bacterial meningitis presenting as fever and seizure is 0.4–1.2%. Signs of meningitis (meningism, petechiae, coma) are usually present but may be absent in 30%.³³ Children with meningitis but no meningism either have complex seizures (prolonged, partial, or multiple) or symptoms suggestive of meningitis (unwell for three days or more, vomiting or drowsy at home, seen by a doctor in the previous 48 hours). Children with simple febrile convulsions and no symptoms or signs of meningitis are highly unlikely to have bacterial meningitis.³³

In conclusion, early lumbar puncture rapidly confirms or excludes bacterial meningitis in most cases and should be performed when meningitis is suspected unless there is a specific contraindication

(signs of cerebral herniation, signs suggesting a disease other than meningitis or shock). If early lumbar puncture is not done, blood should be taken for culture and meningococcal PCR, but the causative organism will not be identified in 20–50% of cases of bacterial meningitis. Meningitis rarely presents as a simple febrile convulsion, but complex seizures, a prolonged illness, or toxicity are indications for lumbar puncture.

As antibiotic resistance increases paediatricians managing meningitis will have to decide between using empirical broad spectrum antibiotics (potentially encouraging further antibiotic resistance) or early lumbar puncture as the best method to culture the causative organism.⁶

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