6.5. BACTERIAL MENINGITIS

A. CAUSES OF MENINGITIS
B. DIAGNOSIS
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D. FEBRILE CONVULSIONS AND MENINGITIS
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These guidelines have been developed in line with NICE 2010 management of meningitis and meningococcal disease. The full guideline and quick reference guide including flow charts for management can be easily accessed on the NICE website.

A. CAUSES

(i) Meningitis beyond the neonatal period
- Neisseria meningitidis – usually group B
- Streptococcus pneumoniae (rare post prevenar vaccine but CAN occur)
- Haemophilus influenzae (rare post vaccine but CAN occur)
- Tuberculosis (rare but can occur in children with no apparent risk factors)

HSV must be considered if clinical presentation suggests encephalitis.
Other organisms may also cause problems, particularly in children who are immunocompromised or have other risk factors such as VP shunts.
Currently the rate of resistance to cefotaxime is low if infection is acquired in the UK however antibiotic resistance may be an issue with infection possibly acquired elsewhere in the world, including parts of Europe. Discuss with microbiology if you are concerned.

(ii) Neonatal Meningitis
In addition to the organisms mentioned above
- Group B streptococci
- E coli
- Listeria (The addition of high dose amoxicillin is recommended in infants presenting with meningitis up to 3 months of age to cover listeria)

HSV encephalitis must be considered in the septic neonate

B. DIAGNOSIS

Symptoms and signs of meningitis may be very non specific in young children:
Fever, vomiting, poor feeding, drowsiness, apnoeas,
A full fontanelle and neck stiffness may not be present
Older children may present with more classical neck stiffness and headache
Kernig's and Brudinski's sign are often negative in children.

Meningitis must be strongly considered particularly in infants who are unwell with fever without a focus. Equally however a child can have both an otitis media and meningitis.
A purpuric rash suggests meningococcal septicaemia.
BUT All children with meningococcal sepsis will not have meningitis;
Not all children with meningococcal meningitis will have a rash;
Children with non-meningococcal meningitis may have a non blanching skin rash.
6.5. BACTERIAL MENINGITIS

Historically lumbar punctures were often carried out routinely following febrile convulsions but this is no longer routine practice as the risk of meningitis following a febrile convulsion is low. However, in children aged 6 months – 1 year, or children with a prolonged or atypical febrile seizure, meningitis and encephalitis must be considered and appropriate treatment and investigations carried out.

Children with possible meningitis should at a minimum have blood taken for:
- blood cultures
- FBC,
- CRP, U&E, LFT
- coagulation
- where indicated blood gas.
- EDTA Blood for pneumococcal or meningococcal PCR is helpful particularly if antibiotics have already been given. PCR is best done on an early sample but if this is forgotten sometimes the initial FBC sample can be used retrospectively if you discuss with haematology. This sample may also be used for HSV PCR.
- Urine culture is important particularly in infants under 3 months where E coli may cause a UTI and meningitis (see management of febrile child)
- Viral throat swab and stool particularly for enterovirus

C. LUMBAR PUNCTURE

Lumbar puncture is the only way of making a definite diagnosis of meningitis (or not) though imaging may be supportive. Along with blood culture CSF is the only source of identifying the organism which is important for the choice of antibiotics and duration of treatment.

Lumbar puncture is in general a safe, if unpleasant, procedure to have carried out in the absence of contraindications. However, particularly in the presence of cerebral oedema or shock, a lumbar puncture may precipitate cerebral herniation. A head CT scan will help rule out focal pathology but a normal CT in a child with other contraindication does not mean it is safe to carry out a lumbar puncture. DO not delay treatment to perform a CT scan. The decision to perform a CT scan must be discussed with the consultant paediatrician on call and PICU and the child must be stable and have access to appropriate, immediate support in X ray

The following are contraindications to LP
- Reduced or altered conscious level certainly if GCS <9 or fall > 3
- Focal neurological signs
- Signs of raised ICP: Abnormal pupillary responses, elevated BP and bradycardia, abnormal posturing, papilloedema
- CT scan/ imaging suggests raised ICP
- Abnormal clotting or platelet count (Platelets <100)
- Local skin infection at site for LP
- Recent seizure (within 30 min), protracted seizure (> 30min) or tonic seizure
- Fever and purpura where meningococcal disease strongly suspected
- Cardiovascular or respiratory compromise including uncorrected shock (tachycardia and poor perfusion)
6.5. BACTERIAL MENINGITIS

If there is any doubt that the child has a contraindication to perform an LP must be discussed with or reviewed by the paediatric consultant on call.

If you feel a child is highly likely to have meningitis and is too unwell to carry out the procedure treat as you would for meningitis and defer the LP till the child is more stable. Interpretation of CSF findings, cell count, protein and glucose and PCR for microbiological confirmation is quite possible over the first 48 hours, even after antibiotics have been started.

Before carrying out a lumbar puncture verbal consent must be obtained from the parents.

CSF must be sent for:
- C & S and urgent microscopy (clear sterile universal)
- Virology (separate samples clear sterile universal)
- Protein (clear sterile universal)
- Glucose (fluoride tube)
- The microbiology lab should be informed when a CSF sample has been obtained. This is essential in samples obtained out of hours.
- A blood glucose sample (not just a BM) should be obtained just before the LP is carried out where possible.

CSF samples must be phoned through to the microbiology laboratory by the Junior doctor responsible for the child. Please also give them your bleep number or, if you are going off shift, the bleep number of whoever should be phoned the result. Unless you can guarantee an urgent transport is available for the sample organise a taxi to send the sample.

CSF results must be back and reviewed within 4 hours.

If you are phone CSF results please ensure they are written in the case notes and you discuss the results with the family.

CSF volumes needed for good practice

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>Bottle</th>
<th>Volume</th>
<th>No. of drops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell count, gram stain and culture</td>
<td>Plain universal</td>
<td>500-600 µl</td>
<td>10</td>
</tr>
<tr>
<td>Protein</td>
<td>Plain universal</td>
<td>300-400 µl</td>
<td>5</td>
</tr>
<tr>
<td>Glucose</td>
<td>Fluoride (yellow)</td>
<td>300-400 µl</td>
<td>5</td>
</tr>
<tr>
<td>Viral and bacterial PCR</td>
<td>Plain universal</td>
<td>1ml+</td>
<td>15+</td>
</tr>
<tr>
<td>Other studies: neurology, autoimmune, oligoconal bands or TB cultures</td>
<td>Plain universal</td>
<td>1ml+</td>
<td>15+</td>
</tr>
</tbody>
</table>

CSF FINDINGS:

Meningitis can occur in children with normal CSF findings, the general rule should be to treat till cultures are available.
6.5. **BACTERIAL MENINGITIS**

CSF protein and WBC values may be higher and glucose values lower in neonates. This is even more markedly so in preterm infants.

Any polymorphs in the CSF is unusual in the absence of meningitis.

A lymphocytosis may be present in bacterial meningitis and a neutrophil predominance can be seen in viral meningitis initially.

In a traumatic tap you may allow 500-700 RBC per 1 WBC but it may be safest to simply disregard the red cells and count the WBC as for a non traumatic tap.

**NORMAL CSF FINDINGS**

<table>
<thead>
<tr>
<th>Age</th>
<th>Neutrophils</th>
<th>Lymphocytes</th>
<th>Protein</th>
<th>CSF Glucose OR CSF glucose/blood glucose ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 1 month of age</td>
<td>0</td>
<td>&lt; 5</td>
<td>&lt; 0.4</td>
<td>&gt;2.5mmol/l CSF glucose OR &gt; 0.6 (ratio)</td>
</tr>
<tr>
<td>&lt; 1 month of age</td>
<td>0</td>
<td>&lt; 20</td>
<td>&lt; 1.0</td>
<td>&gt;2.1mmol/l CSF glucose OR &gt; 0.6 (ratio)</td>
</tr>
</tbody>
</table>

Preterm neonates and term neonates under 2 weeks of age may have slightly higher protein and cell counts but all infants with values outside those documented in the table above should be commenced on intravenous antibiotics till culture results are available.

**D. TREATMENT**

(i) **STEROIDS**

Dexamethasone 150 micrograms/kg (to a maximum dose of 10mg) every 6 hours for 4 days is recommended in all children over 3 months of age if:

- CSF frankly purulent
- Bacteria seen on gram stain
- CSF cell count > 1000/microlitre
- CSF pleiocytosis and protein > 1g/litre (* if TB is a possibility steroids should not be given without antimycobacterial treatment)
- Dexamethasone can be given within 12 hours of the first dose of antibiotics but where ever possible within 4 hours
- Decision to continue steroids beyond the first 12-24 hours should be discussed with the paediatric or PICU consultant involved
- Decision to give steroids to a child with clinical meningitis who is too unwell to LP should be discussed with the consultant paediatrician or PICU consultant on call

Steroids should not be used to treat meningococcal septicaemia: the use of steroids to treat hypotension unresponsive to vasoactive agents should be directed by the intensive care consultant.
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The risk of GI bleeding is small but needs to be looked out for and may be reduced by the routine use of an H2 blocker or proton pump inhibitor. The risk of steroid reducing CNS penetration of antibiotics is felt to be negligible in the first 48 hours of illness. There is no evidence to suggest steroids given to children consequently found to have a viral meningitis is detrimental.

(ii) **ANTIBIOTICS** *(see also antibiotic guidelines)*

Under 3 months of age:
- Cefotaxime (initial dose 100mg/kg then 50mg/kg IV 6 hrly for infants over 21 days of age. (8hrly if 7-21 days old, 12 hrly if under 7 days old) PLUS
- Amoxicillin (100mg/kg/dose) IV 12 hourly if under 7 days of age; 8 hourly if over 7 days of age.

Infants / Children over 3 months
- Cefotaxime initial dose 100mg/kg then 50mg/kg IV 6 hrly
- (Ceftriaxone 80mg/kg IV once daily may be used in children over 3 months after child is clinically stable (SCH deviation from NICE recommendations)

Proven or possible **meningococcal meningitis**: 7 days cefotaxime / ceftriaxone
- **Hib meningitis**: minimum 10 days cefotaxime / ceftriaxone
- **Pneumococcal meningitis**: minimum of 14 days but may need longer (Discuss with microbiology or ID)
- **Group B streptococcal meningitis**: minimum 14 days but may need longer (Discuss with microbiology or ID)
- **E. coli meningitis**: proven or possible: 21 days cefotaxime
- **Listeria**: 21 days amoxicillin with gentamicin for first 7 days

Presumed meningitis with unknown organism
- Infant / Child > 3 months at least 10 days IV cefotaxime / ceftriaxone
- Infant < 3 months at least 14 days IV cefotaxime / ceftriaxone

(iii) **FLUIDS**

Do not restrict fluids unless there is evidence of:
- Raised intracranial pressure
- SIADH
- Signs of shock should be treated with 20ml/Kg 0.9% sodium chloride
- If shock persists a further bolus of 20ml/kg 0.9% sodium chloride or 4.5%albumin should be given. Intensive care should be informed if a second fluid bolus has been necessary

E. **FOLLOW UP**

Children should have hearing screening done as soon as they are fit to and certainly within 4 weeks. If may be possible to arrange before discharge from hospital
All children should be reviewed by a paediatrician in out patients, where possible within 4-6 weeks of discharge (NICE guidance).

Any child identified with pneumococcal meningitis, haemophilus type b or meningococcal group C meningitis will need further investigation and notification
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as a possible vaccine failure. The immunology/ID team can coordinate the follow-up serology and investigation in these children.

Any previously unvaccinated child with pneumococcal meningitis should be offered vaccination with Prevenar 13 (under 5’s) or Pneumovax or Prevenar 13 (over 5’s). Please discuss with the immunology/ID team for advice as pneumococcal meningitis in children over 5 years old is unusual and may suggest an underlying immunodeficiency.

Children where there is a family history of meningococcal disease merit complement studies (CH50/ APCH50) but these should be carried out when the child is recovered.

Children with recurrent meningitis or a history of other serious invasive infections need referred to the immunology/ID team for further investigation.

ALL MENINGITIS IS NOTIFIABLE TO THE CONSULTANT IN COMMUNICABLE DISEASES. See notification of infectious disease.

Close contacts will need prophylaxis if meningococcal or Haemophilus influenzae is suspected.

References:

NICE 2010 Management of meningitis and meningococcal disease
Clinical Guidelines Royal Melbourne Children’s Hospital

(Section 6.5. reviewed by Dr F. Shackley, April 2015)