Neuroinfections

Department of Pediatric Neurology
Medical University of Warsaw
DEFINITION

Infectious diseases of various etiology that involve the nervous system
CLASSIFICATION

Localization

1. diffused
   • Meningitis - inflammation of meninges
   • Encephalitis - brain inflammation
   • Myelitis - spinal cord inflammation

2. Limited
   • Brain abscess
   • Epidural abscess
   • Subdural abscess

Etiology

• Bacterial
• Viral
• Fungal
• Parasitic
• Prion diseases

Depending on the clinical course

1. Acute (hours, days)
2. Chronic (days, weeks)

Depending on cerebrospinal fluid results

1. Purulent
2. Non-purulent (aseptic)
EPIDEMIOLOGY

- Morbidity: 6 – 8/100 thou./year
- Mostly among children up to 4 years of age: 40/100 thou./year
ETIOLOGY

• Bacterial – etiology is age dependent
  • Borrelia burgdorferi – it is a bacteria but the clinical presentation is more similar to viral infection (aseptic infection)

• Viral – mostly enteroviruses, tick-borne encephalitis virus, mumps virus, measles, herpes viruses, flu viruses

• Fungal – i.a. Candida spp., Cryptococcus, Aspergillus

• Parasitic – i.a. Toxoplasma gondi

• Prion diseases
Bacterial meningitis – etiology depending on age

<table>
<thead>
<tr>
<th>Age</th>
<th>Pathogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborns</td>
<td>S.agalactiae, E.coli, Klebsiella spp., gram-negative intestinal bacteria, L.monocytogenes</td>
</tr>
<tr>
<td>Newborns (hospital-acquired infection)</td>
<td>Staphylococci, gram-negative intestinal bacteria, P.aerusinosa</td>
</tr>
<tr>
<td>Infants up to 3 months of age</td>
<td>N.meningitidis, H.influenzae, S.pneumoniae</td>
</tr>
<tr>
<td>Older infants, children, adults</td>
<td>N.Meningitidis (in Poland type B and C), S.pneumoniae, H.influenzae (mostly type b (Hib)), L.monocytogenes</td>
</tr>
</tbody>
</table>

Viral and other aseptic (non-purulent)* infections

<table>
<thead>
<tr>
<th>Viruses</th>
<th>Bacteria</th>
<th>Fungus</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>• enteroviruses (echo, coxsackie, polio)</td>
<td>• Borrelia burgdorferi sensu stricto</td>
<td>• Candida albicans</td>
<td>• Toxoplasma gondii</td>
</tr>
<tr>
<td>• tick-borne encephalitis virus</td>
<td>• Bartonella henselae (cat-scratch disease)</td>
<td>• Cryptococcus neoformans</td>
<td></td>
</tr>
<tr>
<td>• Mumps virus</td>
<td>• Mycoplasma pneumoniae</td>
<td>• Histoplasma capsulatum</td>
<td></td>
</tr>
<tr>
<td>• HSV-2</td>
<td>• Chlamydia psitacci</td>
<td>• Blastomyces dermatitidis</td>
<td></td>
</tr>
<tr>
<td>• EBV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Influenza viruses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• CMV</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Aseptic (non-purulent) infection – infections in which the cerebrospinal fluid results are similar to viral infection rather than typical bacterial*
Pathogenesis – how pathogens are transmitted to the nervous system

- **Blood-borne transmission**
- From neighbouring organs through continuity i.a. sinusitis, middle ear infection, skull trauma
  - Neuronal transmission – some viruses may infect the central nervous system (CNS) by migration through the axons (herpes viruses, polio, coronaviruses, rabies)
The stages of infection – blood-borne transmission

- The source of infection – infected person or carrier
- Colonization of nasopharyngeal cavity
- Local pathogen propagation
- Pathogen transmission to the blood – BACTEREMIA, VIREMIA
- Infiltration of the blood-brain barrier
- Inflammation of subarachnoid space
- Damage and increased permeability of the blood-brain barrier
- Impaired absorption of cerebrospinal fluid -> subarachnoid space edema
  - Vascular edema
  - Cytotoxic edema
  - Increased intracranial pressure (ICP)
  - Brain vasculitis
Inflammation caused by the infiltration of the pathogen into the cerebrospinal fluid. It involves pia mater, arachnoid, and subarachnoid space. If untreated, it may extend to neuronal tissue (encephalitis or encephalomeningitis).
Bacterial central nervous system (CNS) infections - symptoms

Symptoms are usually acute

OLD CHILDERN AND ADULTS

- headache
- fever
- vomits and nausea
- photophobia
- meningeal signs (not all required)
- reluctance to eating and drinking
- sleepness
- irritability
- consciousness disturbances, emotional lability
- seizures
- focal neurological signs – i.a. cranial nerves paralysis, paresthesia, paralysis

These signs suggest the involvement of neuronal tissue (encephalitis)

NEWBORNs AND INFANTS

- sleepness
- irritability
- reluctance to eating, vomits
- fever or hypothermia!!!
- opisthotonus
- elevated, tense, pulsing fontanelle
- seizures
- General hipo/hipertonia (change of muscle tone)
- Focal neurological signs – i.a. hemiplegia, cranial nerves paralysis

IMPORTANT: typical meningeal signs may be not observed!!!
(due to fontanelle -> „safety vent” for increased intracranial pressure (ICP)
# Meningeal signs

<table>
<thead>
<tr>
<th>Sign</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck stiffness (nuchal rigidity)</td>
<td>It is an inability to flex the neck forward due to <strong>rigidity</strong> of the neck muscles.</td>
</tr>
<tr>
<td>Brudzinski’s neck sign (upper)</td>
<td>This is an involuntary flexion of the lower extremities when the neck is passively flexed.</td>
</tr>
<tr>
<td>Brudzinski’s sympheseal sign (lower)</td>
<td>Pressure on the pubic symphysis elicits a reflex flexion and abduction of the lower extremities</td>
</tr>
<tr>
<td>Brudzinski’s cheek sign</td>
<td>Applying the pressure on both cheeks inferior to the zygomatic arch leads to spontaneous flexion of the forearm and arm</td>
</tr>
<tr>
<td>Kernig’s sign</td>
<td>The patient is kept in a supine position, hip and knee are flexed to a right angle, and then the knee is slowly extended by the examiner. The sign is positive when there is resistance during the knee extension +/- pain</td>
</tr>
<tr>
<td>Herman’s sign</td>
<td>Big toe extension in response to neck flexion</td>
</tr>
<tr>
<td>Flatau sign</td>
<td><strong>Mydriasis</strong> (pupillary constriction) in response to neck flexion (assisted if necessary)</td>
</tr>
<tr>
<td>Amoss’ sign</td>
<td>the patient sits up from a supine position by supporting himself with his arms placed behind him</td>
</tr>
</tbody>
</table>
Bacterial meningitis – characteristic depending on the etiology

<table>
<thead>
<tr>
<th></th>
<th>N. meningitidis</th>
<th>S. pneumoniae</th>
<th>H. influenzae</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Additional characteristic features</strong></td>
<td><strong>Hemorrhagic rash</strong> (10-50%)</td>
<td>Middle ear infection, pneumonia Neuroinfection may recur</td>
<td>Middle ear infection</td>
</tr>
<tr>
<td><strong>Predisposed age groups</strong></td>
<td>Children &lt; 4yrs, teenagers, young adults</td>
<td>Children &lt; 2 yrs, adults &gt; 65 yrs</td>
<td>Children &lt; 2 yrs</td>
</tr>
<tr>
<td><strong>Risk factors</strong></td>
<td>Immunosuppression, asplenia or post-splenectomy, autoimmunological diseases, bad socioeconomic conditions</td>
<td>Immunosuppression, pre-term children with bronchopulmonary dysplasia, CNS abnormalities, CSF leak</td>
<td>Immunosupression</td>
</tr>
<tr>
<td><strong>Disease dynamics</strong></td>
<td><strong>Very</strong> fast (a few hours)</td>
<td>Fast (dozen of hours)</td>
<td>Fast (dozen of hours) or moderate (12-48h)</td>
</tr>
<tr>
<td><strong>Neurological consequences</strong></td>
<td>20%</td>
<td>20-50%</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Mortality</strong></td>
<td>10-12%, in septic shock even 50%</td>
<td>10-25%</td>
<td>5%</td>
</tr>
</tbody>
</table>
Hemorrhagic rash in meningococcal sepsis

Fever with spots or rashes that do not fade under pressure is a medical emergency.
Viral and aseptic neuroinfections – symptoms

- Variable:
  - From asymptomatic or mild
  - To acute and severe infections with consciousness disturbances, seizures, and focal neurological signs

- Signs of neuroinfections may occur after a few days of unspecified flu-like or gastrointestinal symptoms (two-stage course)

- Symptoms may be unspecified e.g. headache and facial nerve palsy – they may indicate on neuroborreliosis
Natural course

- Depending on pathogen and localization of the infection (meningitis vs encephalitis and myelitis)

- Bacterial infections, especially typical (septic/purulent), are usually severer than viral and aseptic infections

- Very severe infection may rapidly progress to shock and death
  - Remember about haemorrhagic rash -> glass test-> meningococcal sepsis!!!
Neuroinfections – Diagnostic workup

- Clinical presentation – the suspicion of neuroinfection is an indication for the lumbar puncture. Assess the basic parameters (heart and respiratory rate, blood pressure, saturation, temperature) and general patient’s state. Medical interview and physical examination are the most important - you do not need additional tests to suspect neuroinfection!

- Lumbar puncture
- Laboratory tests
- Fundoscopic examination
- Neuroimaging studies
- Electroencephalography (EEG)

Stabilization of the patient’s condition and quick antibiotics introduction are the priority!
If there are contraindications for the lumbar puncture -> begin the treatment with antibiotics before diagnostic workup!
Diagnostic standarts – Time!

- Time from the first contact with a doctor to the beginning of empiric treatment should not exceed 3 hours.

- If you suspect meningococcal infection it should be up to 30 minutes!!!
Lumbar puncture

Cerebrospinal fluid

The spinal needle is usually inserted between the 3rd and 4th lumbar vertebra.
## Contraindication to the lumbar puncture

**Absolute**
- **Signs of increased intracranial pressure (ICP)** (bradycardia, increased blood pressure, breathing disturbances, optic disc edema)
- Coagulopathy – platelet level <50 thou/mm3 or INR > 1.6, or DIC
- Cardiorespiratory failure, shock
- Regional skin infection in the lumbar region

**Conditional**
- Coagulopathy – platelet level 50 – 100 thou/mm3, INR 1,4 – 1,6
- Deformation of the lumbar spine
- Significant dehydration
- If performing of the lumbar puncture will significantly delay the introduction of antibiotics

Increased intracranial pressure is the most important contraindication for the lumbar puncture! -> the risk of brainstem herniation -> pressure on the brainstem -> cardiorespiratory failure and sudden death
Before the lumbar puncture

- Exclude the contraindications:
  - Increased ICP (fundoscopic examination, neuroimaging studies (computer tomography))
  - Laboratory tests: blood count, coagulogram, blood culture
  - Assess the anatomical structures and skin condition in the lumbar region
  - The glucose level in the blood (for the proper interpretation of CSF results)

- Obtain the written consent for the procedure
Computer tomography (CT) before the lumbar puncture

CT may exclude increased ICP or indicate other abnormalities: brain edema, anatomical abnormalities, brain tumor.

However, there are no recommendations for routine CT scan before the lumbar puncture. Indications for CT in patients suspected of neuroinfection:

- Consciousness disturbances
- CSF leak
- Hydrocephalus or ventriculoperitoneal shunt
- Focal neurologic deficit (eg, dilated nonreactive pupil, gaze palsy, or arm or leg drift)
- Recent head trauma or neurosurgical intervention
- Papilledema
- Immunocompromised state
- History of CNS disease (eg, mass lesion, stroke, or focal infection)
- Seizure within 1 week of presentation

However, postpone the CT if it significantly delays the performance of the lumbar puncture or antibiotics treatment. Although remember to exclude the increased ICP before the lumbar puncture by other methods e.g. fundoscopic exam
Cerebrospinal fluid tests

• Basic test
• Smear
• Bacterial culture
• Serological and molecular tests (specific antibodies, PCR)
## CSF findings depending on etiology

<table>
<thead>
<tr>
<th></th>
<th>Normal results &gt; 12 months of age</th>
<th>Bacterial</th>
<th>Viral</th>
<th>Tuberculosis</th>
<th>Borreliosis/syphilis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Color and clarity</strong></td>
<td>Clear</td>
<td>Yeallow or green, cloudy</td>
<td>Clear</td>
<td>Clear</td>
<td>Clear</td>
</tr>
<tr>
<td><strong>Cytosis (in ul)</strong></td>
<td>≤ 5</td>
<td>&gt; 1000</td>
<td>Dozen to hundreds</td>
<td>Dozen to hundreds</td>
<td>Dozen to hundreds</td>
</tr>
<tr>
<td><strong>CSF smear</strong></td>
<td>Lymphocytic</td>
<td>Neutrophilic</td>
<td>Lymphocytic</td>
<td>Lymphocytic</td>
<td>Lymphocytic</td>
</tr>
<tr>
<td>Protein concentration [mg/dl]</td>
<td>15 - 45</td>
<td>↑↑ (&gt;100)</td>
<td>N lub ↑ (50-200)</td>
<td>↑↑ (&gt;100)</td>
<td>N lub ↑ (50-200)</td>
</tr>
<tr>
<td>Glucose level: CSF/serum</td>
<td>≥ 0,6</td>
<td>&lt; 0,4</td>
<td>&gt; 0,6 or rarely decreased</td>
<td>&lt; 0,4</td>
<td>0,6 or rarely decreased</td>
</tr>
</tbody>
</table>

Differential diagnosis

- Irritation of meninges (meningismus) – meningeal signs without abnormalities in CSF
- Increased ICP due to other causes e.g. brain tumor
- Subarachnoid haemorrhage, stroke
- Drug poisoning
- Severe dehydration or metabolic imbalance (including diabetes)
Treatment – empiric antibiotic therapy

At least 2 intravenous (i.v) antibiotics in maximal doses

• Newborns:
  • Ampicillin + cefotaxime
  • Ampicillin + aminoglycoside

Hospital-aquired infections: ceftazidime + vancomycin

• Infants, older children, adults:
  • Cefalosporin III generation (ceftriaxone, cefotaxime) + vancomycin
  (in infants 1-3 months: consider addition of ampicillin)
Empiric treatment depending on the risk factors

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Antibiotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture of the skull base bones</td>
<td>Cefotaxime OR ceftriaxone + vancomycin</td>
</tr>
<tr>
<td>Injury penetrating to the CNS</td>
<td>Ceftazidime OR cefepime OR meropenem + vancomycin</td>
</tr>
<tr>
<td>After neurosurgery</td>
<td>Ceftazidime OR cefepime OR meropenem + vancomycin</td>
</tr>
<tr>
<td>CNS infections transmitted through ventriculoperitoneal shunts</td>
<td>Ceftazidime OR cefepime or meropenem + vancomycin</td>
</tr>
</tbody>
</table>

## Antibiotic treatment – Dosage

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th>Newborns</th>
<th>Infants and children</th>
<th>Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-7 days</td>
<td>8-28 days</td>
<td></td>
</tr>
<tr>
<td>Amikacin</td>
<td>15-20 mg/kg/day in 2 divided doses</td>
<td>30 mg/kg/day in 3 divided doses</td>
<td>20-30 mg/kg/day in 3 divided doses</td>
</tr>
<tr>
<td>Ampicillin</td>
<td>150-300 mg/kg/day in 3 divided doses</td>
<td>300-400 mg/kg/day in 3-4 divided doses</td>
<td>300-400 mg/kg/day in 4-6 divided doses</td>
</tr>
<tr>
<td>Cefotaxime</td>
<td>100-150 mg/kg/day in 2-3 divided doses</td>
<td>150-200 mg/kg/day in 3-4 divided doses</td>
<td>225-300 mg/kg/day in 3-4 divided doses</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td>100-150 mg/kg/day in 2-3 divided doses</td>
<td>150 mg/kg/day in 3 divided doses</td>
<td>150 mg/kg/day in 3 divided doses</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>-</td>
<td></td>
<td>80-100 mg/kg/day in 1-2 divided doses</td>
</tr>
<tr>
<td>Meropenem</td>
<td>-</td>
<td></td>
<td>120 mg/kg/day in 3 divided doses</td>
</tr>
<tr>
<td>Vancomycin</td>
<td>20-30 mg/kg in 2-3 doses</td>
<td>30-45 mg/kg in 3-4 doses</td>
<td>60 mg/kg/day in 4 divided doses</td>
</tr>
</tbody>
</table>

Treatment of viral neuroinfections

**Herpes viruses** (effective in HSV and VZV infections and implemented as empiric treatment of aseptic infection):
- Acyclovir i.v. 10 mg/kg every 8 hours

**CMV** (not in empiric treatment):
- Gancyclovir i.v. 5 mg/kg every 12 hours
Supportive treatment – etiology independent

Anti-edema therapy (20% mannitol, Dexamethasone, Furosemide, elevation of the head up to 20-30 degree), treatment of the metabolic abnormalities, anti-seizure (antiepileptic) treatment

Antipyretic treatment e.g.:

• Paracetamol every 4-6 h
  • i.v. 7.5 mg/kg/dose in child < 10 kg OR 15 mg/kg/dose in child > 10 kg
  • p.o. 15 mg/kg/dose p.r 25 mg/kg/dose
  • Older children (> 12 years) and adults i.v. lub p.o 500-1000 mg/dose
• Ibuprofen every 6 – 8 h
  • p.o., p.r. 5-10 mg/kg/dose
  • Older children (> 12 years) and adults p.o 200-400 mg/dose

Dexamethasone: 0,4 mg/kg every 12 hours for 2 days
Dehydration: 0,9% NaCl 20 ml/kg i.v bolus or within 1-2 hours depending on the clinical condition
Hypoglycemia: with consciousness disturbances: 10% glucose 2-2,5 ml/kg V=2-3 ml/min
Coagulopathy: FFP 10-15 ml/kg
Seizures: Diazepam p.r 0,5 mg/kg or i.v 0,2 mg/kg
Brain edema: 20% mannitol 2-2,5 ml/kg infusion within 20-30 min
Empiric treatment should be replaced with pathogen-specific treatment as soon as possible

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Treatment duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neisseria meningitidis</td>
<td>7 days</td>
</tr>
<tr>
<td>Haemophilus influenza typ b</td>
<td>7-10 days</td>
</tr>
<tr>
<td>Streptococcus pneumoniae</td>
<td>10-14 days</td>
</tr>
<tr>
<td>Streptococcus agalactiae</td>
<td>14-21 days</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>14 days</td>
</tr>
<tr>
<td>Listeria monocytogenes, Pseudomonas aeruginosa, Gram-negative gastrointestinal bacteria</td>
<td>&gt; 21 days</td>
</tr>
<tr>
<td>Unknown etiology</td>
<td>10-14 days</td>
</tr>
<tr>
<td>HSV virus</td>
<td>21 days</td>
</tr>
</tbody>
</table>
The supervision of the diagnosis and treatment of bacterial neuroinfections

• KORUN - National Reference Centre for Bacterial Infections of the Central Nervous System
• KORLD- National Reference Centre for Antimicrobial Susceptibility Testing
Particular neuroinfections
Tick-borne encephalitis

- Virus transmitted by ticks (Ixodes)
- Two subtypes of the disease: European – milder and far-eastern – severer
- Seasonality: spring and summer
- Time of incubation: 7 – 14 days
- 35 – 59% of patients present focal neurological deficits. A long time of convalescence
- Bi-phasic clinical course

<table>
<thead>
<tr>
<th>Phase 1 - preliminary</th>
<th>Phase 2 – symptomatic (about 50% of patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flu-like symptoms:</td>
<td>Meningitis: fever, headache, dizziness, vomit, meningeal signs</td>
</tr>
<tr>
<td>▪ Malaise,</td>
<td>Encephalitis: consciousness disturbances, ataxia, aphasia, seizures, cerebral nerves palsy, hemiplegia, etc.</td>
</tr>
<tr>
<td>▪ Weakness,</td>
<td>Encephalomeningitis</td>
</tr>
<tr>
<td>▪ Headache and neck pain,</td>
<td>Myelitis: limb paresis (upper&gt;lower), paresthesia, sphincter disturbances</td>
</tr>
<tr>
<td>▪ Muscle pain,</td>
<td></td>
</tr>
<tr>
<td>▪ Eyeballs pain,</td>
<td></td>
</tr>
<tr>
<td>▪ Nausea, vomit, stomach ache, diarrohea,</td>
<td></td>
</tr>
<tr>
<td>▪ Subfebrile state</td>
<td></td>
</tr>
<tr>
<td>Symptoms last for about a week</td>
<td></td>
</tr>
</tbody>
</table>
Tick-borne encephalitis

Among all infected patients about:

• 30% do not develop any symptoms
• 30%–50% develop only phase-1 symptoms
• up to 30% develop full, bi-phasic clinical course with CNS involvement

Incidence rate is higher among men than women

• Severer clinical course in old people
• Up to 46% patients develop long-term neurological complications during phase-2
Tick-borne encephalitis in children

Milder clinical course in children. However:

- about 20%–30% of pediatric patients develop meningitis and encephalitis
- about 25% of children develop long-term neurological complications
- about 2% of children develop persistent neurological consequences
Tick-borne encephalitis – laboratory tests

1. **SERUM:**
   a. Leucocytosis
   b. Elevated CRP level
   c. Elevated erythrocyte sedimentation rate (ESR)
   d. Detection of specific antibodies (IgG and IgM subtype)

2. **CSF**
   a. Cytosis, usually lymphocytes
   b. Protein of 50-200 mg/dl
   c. Detection of specific antibodies (IgG and IgM subtype) – it confirms the diagnosis
Tick-borne encephalitis - treatment

1. No specific treatment
2. Only a symptomatic treatment: anti-edema, anti-pain, antipyretic, fluids, immunoglobulins

Tick-borne encephalitis – long-term consequences

- Ataxia,
- consciousness disturbances,
- diplopia,
- urine incontinence or retention,
- paresis or paralysis (sometimes involving respiratory muscles),
- dysphagia,
- dysarthria
NEUROBORRELIOSIS

- **Etiology**: Borrelia burgdorferii (bacteria)
- **Transmitter** – Tick (*Ixodes*)
- **Time of incubation**: 7-30 dni
- **The nervous system is involved in about 15% of cases (both peripheral and central nervous system)**
  - Lymphocytic meningitis (aseptic)
  - Cranial nerve palsy (mostly facial nerve, also bilaterally)
  - Radiculopathy
  - Unspecified symptoms e.g. headaches
- **Diagnosis**: detection of specific antibodies in serum and CSF (ELISA – screening test, Western Blot – confirming test)
- **Treatment**: depending on age and localization of the infection (peripheral vs central nervous system)
- **Treatment duration**: 21 days

http://www.bristoluniversitytickid.uk/
# Treatment of neuroborreliosis

<table>
<thead>
<tr>
<th>Symptoms/localization</th>
<th>Age group</th>
<th>First-choice drugs</th>
<th>Second-choice drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Involvement of cranial or peripheral nerves</strong></td>
<td>Adults and children &gt; 12 yrs</td>
<td><strong>Doxycyclinum p.o</strong> 2x100 mg or 1x200 mg for 21 days</td>
<td>Amoksycylina p.o 3x1g przez 21 dni</td>
</tr>
<tr>
<td></td>
<td>Children 9 – 12 yrs</td>
<td><strong>Doxycyclinum p.o</strong> children &lt; 45 kg: 1 day - 5 mg/kg in 2 divided doses, since 2nd day - 2.5 mg/kg/day in 1-2 divided doses for 21 day If the symptoms are severe, continue the dose of 5 mg/kg/day</td>
<td>Amoksycylina p.o &lt;33 kg: 3x 30 mg/kg/dawkę przez 21 dni</td>
</tr>
<tr>
<td></td>
<td>Children &lt; 9 yrs</td>
<td><strong>Amoxicillin p.o</strong> children &lt;33 kg: 3x 30 mg/kg/dose for 21 days</td>
<td></td>
</tr>
<tr>
<td><strong>Involvement of the central nervous system</strong></td>
<td>Adults and children &gt; 12 yrs</td>
<td><strong>Ceftriaxone i.v</strong> 2x 2g lub 1x 4g for 21 days</td>
<td><strong>Doxycyclinum p.o</strong> 2x 200 mg or 1x 400 mg for 21 days</td>
</tr>
<tr>
<td></td>
<td>Children 9 – 12 yrs</td>
<td><strong>Ceftriaxone i.v</strong> &lt; 50 kg: 1x 80 mg/kg (max. 4 g) for 21 days</td>
<td><strong>Doxycyclinum p.o</strong> children &lt; 45 kg: 1 day - 5 mg/kg in 2 divided doses, since 2nd day - 2.5 mg/kg/day in 1-2 divided doses for 21 day If the symptoms are severe, continue the dose of 5 mg/kg/day</td>
</tr>
<tr>
<td></td>
<td>Children &lt; 9 yrs</td>
<td><strong>Ceftriaxone i.v</strong> &lt; 50 kg: 1x 80 mg/kg (max. 4 g) for 21 days</td>
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Based on NICE 2018 recommendations
Tick-borne infections – prophylactics

1. Adequate clothes
2. Repellents
3. Anti-tick-borne encephalitis vaccine
Herpes virus’ encephalitis (HSV)

- HSV virus (>95% HSV-1)
- Mostly due to primary infection -> the virus is transmitted from mouth cavity through axons to the central nervous system
- Mostly newborns, children between 6 months and 4 years of age, and adults
- It constitute for about 10% of all encephalitis
- Symptoms:
  - At the begining - unspecified (fever, upper respiratory tract infection, headache, vomit)
  - Subsequently, neurological symptoms (seizures, paresthesia, paresis, memory deficits, aphasia, hallucinations, consciousness disturbances)
- Diagnosis: CSF examination including molecular tests for viral DNA, neuroimaging studies – lesions in the temporal lobes
- Treatment:
  - Acyclovir i.v. 10 mg/kg every 8 h for 21 days
  - Symptomatic treatment
Local CNS infections – brain abscess

- Etiology: bacteria (staphylococci, streptococci, anaerobic bacteria), fungus
- Brain abscess is often secondary to other neighboring infections e.g. sinusitis, middle ear infections, a periodontal abscess
- Higher risk in patients with immunosuppression (be aware of atypical etiology)
- Symptoms: headache, fever, focal neurological deficits
- Diagnosis: neuroimaging studies (CT, MRI)
- Treatment: neurosurgical + antibiotics
Currently, we may prevent some neuroinfections and neurological complications by **vaccines**

**Obligatory vaccines in Poland:**
- Anti-Hib (anti *Haemophilus influenzae typu b*)
- Anti- Streptococcus pneumoniae (several serotypes)
- Anti-rotaviruses

**Vaccination for „forgotten” diseases:**
- Tuberculosis
- Polio
- Mumps, measles, rubella

**Recommended but not obligatory vaccination in Poland:**
- Anti- Neisseria meningitidis
- Anti-tick-borne encephalitis
- Anti-influenza vaccine
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* szczepienie powinno być przeprowadzone przed wpisaniem dziecka z oddziału noworodkowego, **Td obowiązkowe lub Tdap zalecane,
Thank you for your attention

Klinika Neurologii Dziecięcej WUM
neurologia.dsk@uckwum.pl