**Neuroimaging (GENERAL)**

Last updated: June 3, 2019

**GENERAL PRINCIPLES**

It is conventional for tomographic axial images (CT, MRI) - *left side of brain is on right of figure!!!*

**MRI** is more sensitive (than CT) for most lesions affecting brain / spinal cord parenchyma.

N.B. MRI cannot detect calcifications!

**CT** is more sensitive (than MRI) for osseous detail and acute hemorrhage.

N.B. CT has many artefacts in posterior fossa!

CT is preferable in acute trauma!

**Angiography** is very sensitive in cases where small-vessel detail is essential for diagnosis.

CT signal is dependent on *electron* density; MRI signal – *proton* density.

**MOST USEFUL IMAGING MODALITIES**

(usually also most cost-effective)

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<tr>
<th>NEUROLOGIC PROBLEM</th>
<th>IMAGING</th>
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<tr>
<td>Nonlocalized symptoms</td>
<td>MRI (without and with contrast) - most sensitive for initial imaging</td>
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<td>Diseases affecting primarily skull</td>
<td>CT (without contrast), X-ray</td>
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<tr>
<td>Acute hemorrhage</td>
<td>CT (without contrast) - best imaging method</td>
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<td>Subacute hemorrhage</td>
<td>MRI</td>
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<td>Highly suspected aneurysm (e.g. acute CN3 palsy, SAH on CT)</td>
<td>Angiography - definitive</td>
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<td>Familial history of aneurysm or predisposing condition (e.g. polycystic kidney disease)</td>
<td>MRA - noninvasive and excellent screening</td>
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<tr>
<td>Suspected stroke</td>
<td>CT - fast + can detect hemorrhage or ischemic infarction</td>
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<td></td>
<td>Diffusion-weighted MRI - fast + extremely sensitive for acute stroke</td>
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<tr>
<td>NEUROLOGIC PROBLEM</td>
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<tr>
<td>Carotid or vertebral <strong>dissection</strong></td>
<td><strong>MRI / MRA</strong></td>
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<td>Vertebrobasilar insufficiency</td>
<td><strong>MRI / MRA</strong></td>
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<tr>
<td>Carotid stenosis</td>
<td>Doppler ultrasound (screening), <strong>MRA / CTA, angiography</strong> (definitive)</td>
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<tr>
<td>Vascular malformations</td>
<td><strong>MRI</strong> (initial), <strong>angiography</strong> (definitive)</td>
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<td>Meningeal disease</td>
<td><strong>MRI (with contrast)</strong></td>
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<tr>
<td>Cranial neuropathy</td>
<td><strong>CT</strong> (to evaluate skull-base foramina) + <strong>MRI (with contrast)</strong>; of cranial nerves, only CN2 can be directly visualized by <strong>CT</strong></td>
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<tr>
<td>Headache</td>
<td><strong>MRI</strong></td>
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<tr>
<td>Suspected neoplasm / MS / white matter disorders / infection / inflammation</td>
<td><strong>MRI (without and with contrast)</strong></td>
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<tr>
<td>Dementia work-up</td>
<td><strong>MRI (without contrast); rarely is contrast helpful</strong> - first test - detects possible causative lesions. <strong>PET / SPECT</strong> - may be helpful</td>
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<tr>
<td>Seizures / epilepsy</td>
<td><strong>MRI (without and with contrast)</strong> - first test - to detect any causative lesion <strong>SPECT / PET / MRS / fMRI</strong> - other useful techniques</td>
</tr>
<tr>
<td>Head trauma</td>
<td><strong>CT (without contrast)</strong> - acute <strong>MRI</strong> - follow-up</td>
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<tr>
<td>Intrinsic spinal cord lesion further see D70 p.</td>
<td><strong>MRI</strong> (without and with contrast)</td>
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<tr>
<td>Extradural spinal process further see D70 p.</td>
<td><strong>MRI (without and with contrast)</strong> <strong>CT myelogram</strong> - particularly useful for cervical spine degenerative disease</td>
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<td>Peripheral nerve disorders</td>
<td><strong>MRI</strong></td>
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<tr>
<td>Paranasal sinus disorders</td>
<td><strong>CT</strong> (exquisite bone detail highlighted by air); intracranial extent of neoplasm / infection is better evaluated by <strong>MRI</strong></td>
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<td>Middle ear disorders</td>
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<tr>
<td>Orbit disorders</td>
<td><strong>CT / MRI</strong></td>
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N.B. **dural enhancement** and **pial enhancement** have clearly different appearances - never use term "meningeal enhancement"!

**INTRA VENOUS CONTRAST ENHANCEMENT**

a) **iodinated** contrast media (for CT) see p. D49 >>

b) paramagnetic media usually containing **gadolinium** (for MRI)

c) radionuclides

Although many lesions are seen better with contrast medium, added information is often trivial compared with added cost and increased time of examination.
I. **Areas of increased vascular permeability** (CT and MRI contrasts provide identical information*)

*MRI has higher contrast-to-noise ratios - more sensitive for detecting contrast enhancement than is CT

- BBB is responsible for lack of significant enhancement in normal brain parenchyma (i.e. intravenous contrast only slightly increases density of normal brain).
- any BBB alterations → nonspecific contrast enhancement in brain parenchyma & leptomeninges.
- incidence of reaction is much lower with MRI contrast agents (vs. CT contrasts) - MRI is generally modality of choice when contrast-enhanced CNS examination is indicated.

Clinical situations in which contrast is **recommended**:
1. Infection
2. Inflammation
3. Neoplasia
4. Process thought to involve leptomeninges, nerve roots
5. Seizures
6. Spinal:
   1) intramedullary lesions
   2) subarachnoid lesions
   3) extradural malignant lesions
   4) postoperative spine (to separate scar [enhances] from recurrent disk [does not enhance])

Clinical situations in which contrast is **not recommended**:
1. Hemorrhagic event
2. Ischemic event
3. Congenital anomaly
4. Head trauma
5. Neurodegenerative disease (dementias, etc)
6. Hydrocephalus
7. Spinal cord – trauma, degenerative disease (not operated)

II. **Abnormal collections of blood vessels** – only for CT (in MRI, vascular enhancement depends on velocity of blood flow and specific MRI sequence used).

**NORMALLY ENHANCING STRUCTURES**

1. Lack of BBB - dural structures (falx and tentorium), pituitary gland, pineal gland.
2. Blood (contains contrast material) - vessels (esp. slowly flowing blood within cavernous sinus or cortical veins), choroid plexus.

**ALLERGY TO CONTRAST**
(e.g. patient allergic to shellfish)

Premedication:
1. **PREDNISONE** (50 mg oral) – three doses: 13, 7, and 1 hour before study
2. **DIPHENHYDRAMINE** (50 mg oral) 1 hour before study

**KIDNEY FAILURE**
After *iodinated contrast* – *hemodialysis* on patient’s regular schedule.
After *gadolinium* – *hemodialysis* for three consecutive days (start immediately after MRI).

### PEDIATRIC NEUROIMAGING

‘Child is not small adult’

**SEDATION**
- sedation (or general anaesthesia) is usually required for *young children* (lack of head movement is essential during study) for many procedures
  
a) **PENTOBARBITAL**, 4 mg/kg IM 30 min before CT ± supplementary 2 mg/kg IM 1-1½ hr later.
  
b) **CHLORAL HYDRATE**, 50-75 mg/kg PO 45 min before CT.

### FETAL NEUROIMAGING

- early detection of *congenital malformations* / *destructive lesions* → termination of pregnancy.
  
a) *early pregnancy* – ultrasound; *ventriculomegaly* is most obvious early fetal sign of intracranial abnormality; malformations that are possible to detect in early pregnancy - Chiari II malformation, Dandy–Walker malformation, acrania, agenesis of corpus callosum and holoprosencephaly.  
  
  N.B. *ventricles are normally large* in fetus < 20 weeks’ gestation!  
  N.B. fetal *brain is smooth* with few if any developed sulci - migrational malformations (e.g. agyria) are impossible to detect prior to 18 weeks’ gestation.
  
b) *late pregnancy* – MRI.
  
  N.B. only in some countries (such as France) it is possible for medical reasons to terminate pregnancy very late, close to full term!

### NEONATAL NEUROIMAGING

- to establish as accurate diagnosis as possible – to predict future handicap.

  N.B. *neuroradiology is not useful in establishing normality* - cannot predict future normal neurological development in newborn who has recovered from episode of perinatal hypoxia.

- choice of imaging technique is important - sick newborn may be difficult to transport to radiology department – bedside *sonography* is preferred technique – can detect *periventricular* pathology (but *more peripheral* pathology may be difficult to detect; H: CT/MRI).
- **CT** could wait until at least 6 (preferably 12) months of age (e.g. to give abnormal calcifications time to develop).
- normal ultrasound + normal CT = most major malformations and acquired lesions are excluded → **MRI** (wait until brain is fully mature at ≈ 18 months) - to assess detailed *cortical* anatomy.
- MRI is also used to assess *myelination* course.  

**BIBLIOGRAPHY** for ch. “Diagnostics” → follow this [LINK >>](#)