Neuroimaging (GENERAL)

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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)

| **NEUROLOGIC PROBLEM** | **IMAGING** |
| --- | --- |
| Nonlocalized symptoms | MRI (without and with contrast) - most sensitive for initial imaging |
| Diseases affecting primarily skull | CT (without contrast), X-ray |
| Acute hemorrhage | CT (without contrast) - best imaging method |
| Subacute hemorrhage | MRI |
| Highly suspected aneurysm (e.g. acute CN3 palsy, SAH on CT) | Angiography - definitive |
| Familial history of aneurysm or predisposing condition (e.g. polycystic kidney disease) | MRA - noninvasive and excellent screening |
| Suspected stroke | CT - fast + can detect hemorrhage or ischemic infarction |
| Diffusion-weighted MRI - fast + extremely sensitive for acute stroke |
| Carotid or vertebral dissection | MRI / MRA |
| Vertebrobasilar insufficiency | MRI / MRA |
| Carotid stenosis | Doppler ultrasound (screening), MRA / CTA, angiography (definitive) |
| Vascular malformations | MRI (initial), angiography (definitive) |
| Meningeal disease | MRI (with contrast) |
| Cranial neuropathy | CT (to evaluate skull-base foramina) + MRI (with contrast); of cranial nerves, only CN2 can be directly visualized by CT |
| Headache | MRI |
| Suspected neoplasm / MS / white matter disorders / infection / inflammation | MRI (without and with contrast) |
| Dementia work-up | MRI (without contrast; rarely is contrast helpful) - first test - detects possible causative lesions. |
| PET / SPECT - may be helpful |
| Seizures / epilepsy | MRI (without and with contrast) - first test - to detect any causative lesion |
| SPECT / PET / MRS / fMRI - other useful techniques |
| Head trauma | CT (without contrast) - acute |
| MRI - follow-up |
| Intrinsic spinal cord lesion  [further see D70 p.](http://www.neurosurgeryresident.net/D.%20Diagnostics\D70.%20Spinal%20Imaging\D70.%20Spinal%20Imaging.pdf#Radiological_approach) | MRI (without and with contrast) |
| Extradural spinal process  [further see D70 p.](http://www.neurosurgeryresident.net/D.%20Diagnostics\D70.%20Spinal%20Imaging\D70.%20Spinal%20Imaging.pdf#Radiological_approach) | MRI (without and with contrast) |
| CT myelogram - particularly useful for cervical spine degenerative disease |
| Peripheral nerve disorders | MRI |
| Paranasal sinus disorders | CT (exquisite bone detail highlighted by air); intracranial extent of neoplasm / infection is better evaluated by MRI |
| Middle ear disorders |
| Orbit disorders | CT / MRI |

N.B. *dural enhancement* and *pial enhancement* have clearly different appearances - never use term "meningeal enhancement"!

Intravenous Contrast enhancement

1. **iodinated** contrast media (for CT) [see p. D49 >>](http://www.neurosurgeryresident.net/D.%20Diagnostics\D45-59.%20Neuroimaging%20(X-ray,%20CT,%20MRI,%20PET,%20MRS)\D49.%20CT.pdf#IV_Contrast_for_CT)
2. paramagnetic media usually containing **gadolinium** (for MRI)
3. 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

* 1. pentobarbital, 4 mg/kg IM 30 min before CT ± supplementary 2 mg/kg IM 1-1½ hr later.
  2. chloral hydrate, 50-75 mg/kg PO 45 min before CT.

Fetal Neuroimaging

- early detection of congenital malformations / destructive lesions → termination of pregnancy.

1. ***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.

1. ***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. [see p. A7 (5)](http://www.neurosurgeryresident.net/A.%20Neuroscience%20Basics\A6-11.%20General%20Histology,%20Myelination,%20BBB\A7%20(5).%20Myelination%20Timetable.pdf)

Bibliography for ch. “Diagnostics” → follow this [link >>](http://www.neurosurgeryresident.net/D.%20Diagnostics/D.%20Bibliography.pdf)

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