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

NEUROLOGIC PROBLEM	IMAGING
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.	MRI (without and with contrast)
Extradural spinal process further see D70 p.	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

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. see p. A7 (5)

BIBLIOGRAPHY for ch. "Diagnostics" → follow this LINK >>