Brain Imaging

Common CT attenuation values

<table>
<thead>
<tr>
<th>Structure</th>
<th>Attenuation value in HU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>From -500 To -1000 HU</td>
</tr>
<tr>
<td>Fat</td>
<td>From -10 To - 200 HU</td>
</tr>
<tr>
<td>Water</td>
<td>From 0 To 15 HU</td>
</tr>
<tr>
<td>Brain tissue</td>
<td>From 30 To 40 HU</td>
</tr>
<tr>
<td>Recent hematoma</td>
<td>From 60 To 90 HU</td>
</tr>
<tr>
<td>Calcifications</td>
<td>More than 100 HU</td>
</tr>
<tr>
<td>Bone</td>
<td>From 200 HU and above</td>
</tr>
<tr>
<td>Brain edema and infarction</td>
<td>around 20 HU</td>
</tr>
<tr>
<td>Normal liver parenchyma</td>
<td>around 60 HU</td>
</tr>
</tbody>
</table>

Common MR signal behaviors

- Low signal in T1 and low signal in T2
  - Cortical bone
  - Calcifications
  - Mature fibrous tissue
  - Flowing blood
  - Air (minimal hydrogen)
- High signal in T1 and high signal in T2
  - Subacute blood (extracellular met Hb)
- High signal in T1 and low signal in T2
  - Fat and fat like structures (lipoma, dermoid cyst, ..)
- Low signal in T1 & high signal in T2 [fluid signal]
  - Any normal structure or lesion not included in the previous lists
Examples: CSF, brain edema, most of brain tumours,....
**CT Brain**

**Indications:**

- Congenital anomalies: Hydrocephalus
- Traumatic insults: Fractures & suspected intracranial hage
- Inflammatory lesions: Brain abscess, TB, viral encephalitis...
- Neoplastic lesions: Benign & malignant intracranial neoplasms
- Vascular lesions: Aneurysm, AVM,...
- Miscellaneous: Cerebro vascular stroke, epilepsy,...

**Technique of examination:**

- Patient’s preparation: no preparation is needed unless for patients who need contrast injection or anasesthesia (children, uncooperative patients): In such cases fasting 6 hours before examination is necessary
- Patient’s position: Supine for axial sections, prone for coronal sections
- Scanogram: Lateral
- Contrast medium (whenever indicated): 60 - 80 ml of 60% iodinated contrast agent (urographin, telebrix, urovison, ...) injected intravenously just before the start of examination
- Start line paralleled to the orbito metal line
- Section thickness 10mm [7mm for children]
- Average number of sections 12-14
- Bone window for basal sections (1-4) and soft tissue window for all sections

**Indications for contrast injection:**

Contrast injection is usually judged by the radiologist in charge of the CT unit, generally we do not inject contrast material in these conditions:
- Patients presenting with head trauma or cerebrovascular strokes
- Patients with history of severe allergy to contrast media
- Patients with poor renal function. [creatinine above 3 mg]
Brain anatomy:
- Infraventricular level (posterior fossa cuts)
- Ventricular level (level of the lateral ventricles)
- Supraventricular level (cuts above the ventricles)

Infraventricular level:
- 4th ventricle is the most important anatomical landmark
- Brain stem (anterior to the 4th ventricle) (medulla, pons, midbrain)
- Cerebellum (postero-lateral to the 4th ventricle)
- Cerebellar vermis (posterior to the 4th ventricle in the midline)

1. Fourth ventricle
2. Brain stem
3. Cerebello pontine angle
4. Basilar artery
5. Caudate nuclear (head)
6. Caudate nuclear (body)
7. Lantiform nuclear
8. Thalamus
9. Internal capsule
10. Insula
11. Genu of corpus callosum
12. Splenium of corpus callosum
13. Body of corpus callosum
14. Corona radiate
15. White matter
16. Gray matter
CPA = Cerebello pontine angle
F = Frontal lobe
P = Parietal lobe
O = Occipital lobe
- **Ventricular level**
  - Lower section (Basal ganglia cuts) will show the caudate nucleus, lentiform nucleus, thalamus, internal capsule as well as quadrigeminal cistern like a cup with the midbrain lying in its concavity.
  - Upper section (level of the ventricular body) The body and tail of the caudate nucleus are seen adjacent to the ventricular wall.
  - The ventricles are separated by the septum pellucidum. The grey white matter interface is evident.

- **Supra ventricular level**
  Cerebral hemispheres, grey white matter interface and midline plane

- **Lobar anatomy**

![Diagram showing lobar anatomy](image)

- **Lower section**
  - F = Frontal lobe
  - T = Temporal lobe
  - P = Parietal lobe
  - O = Occipital lobe

- **Upper section**

**Note:**
- P = Patient lobe
- O = Occipital lobe
**Brain MRI**

**General advantages of MRI**
- Multiplanar imaging (axial, sagittal, coronal, oblique, ...)
- No ionizing radiation
- Tissue characterization
- Visualization of vascular structures without the need for contrast injection (signal void phenomena)
- Allow some investigations to be done without contrast injection (MR angiography, MR myelography, MR cholangiography, ...)

**Limitations to MRI**
- Absolute contraindications to MR examination
  - Cardiac pace maker
  - Clipping of an intracranial aneurysm
  - Intraocular metallic FB
- Relative contraindication:
  - Marked obesity → open magnet
  - Colostrophobia → anaesthesia, or open magnet
  - Metallic implants degrading the scan quality
  - Relative high cost + relative limited availability

**Indications of Brain MRI**

Similar to indications of CT brain scan + other indications where MRI is superior to CT such as:
- Diagnosis of certain diseases like white matter lesions, temporal lobe epilepsy and craniocervical junction pathology
- Diagnosis of vascular lesions without the need for contrast injection (signal void phenomena, MR angiography, ...)
- Better assessment of certain anatomic regions such as the posterior fossa, temporal lobes, pituitary and suprasellar areas, ...
- Confirmation of the CT diagnosis of certain lesions by:
  - Better orientation due to multiplanar imaging
  - Tissue characterization (MR can differentiate fluid, fat, blood, ...)
  - Absence of bone artifacts
  - Adequate delineation of blood vessels
**Contrast media:**
Contrast medium for MRI is Gadolinium- DTPA injected intravenously in a dose of 0.1-0.2 ml/kgm body weight.

**MR technique:**
The MR protocol for brain imaging should include:
- Sagittal T1 WIs
- Axial T1 and FLIR weighted images

**NB:** Proton density was an old sequence, now replaced by the FLAIR sequence where CSF is black like T1 images and most of the pathologic conditions show high signal like T2 WIs. Lesion that are similar to CSF (arachnoid cyst, late encephalomalacia,...) will appear black on FLAIR sequence.

- If contrast material is injected we add axial, sagittal and/or coronal TI WIs after contrast injection. Gadolinium only affects the T1 WIs

**NB** The usual section thickness is 5mm with interslice gap of 2mm unless indicated otherwise.
1 Fourth ventricle  11 Genu of corpus callosum
2 Pons  12 Splenium of corpus callosum
3 Cerebello pontine angle cistern  13 Body of corpus callosum
4 Pre pontine cistern & basilar artery  14 Corona radiata
5 Head of caudate nucleus  15 White matter
6 Body of caudate nucleus  16 Gray matter
7 Lentiform nucleus  17 Medulla oblongata
8 Thalamus  18 Upper cervical cord
9 Internal capsule  19 Mid brain
10 Insula

C= Cerebellum, CPA= Cerebello pontine angle, F= frontal lobe,
O= occipital lobe, P= parietal lobe, arrow= aquiduct of sylvius