Cerebro-vascular stroke

CT Terminology
- Hypodense lesion = lesion of lower density than the normal brain tissue
- Hyperdense lesion = lesion of higher density than normal brain tissue
- Isodense lesion = lesion of similar density to the normal brain tissue. The site of this lesion is identified by its mass effect on the adjacent ventricle and sulci

<table>
<thead>
<tr>
<th>Hypodense</th>
<th>Hyperdense</th>
<th>Iso dense</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Right parietal infarction" /></td>
<td><img src="image2" alt="Right temporal hemorrhage" /></td>
<td><img src="image3" alt="Right subacute subdural hematoma" /></td>
</tr>
</tbody>
</table>

CT density [HU]

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

The normal brain density range from 30 - 40 HU
Any lesion with CT density lower than 30 HU will appear hypodense
Any lesion with CT density higher than 40 HU will appear hyperdense
The table shows the approximate CT density of common lesions seen in the brain
Hypo dense lesions

- Right parietal acute infarction
- Left parietal hydatid cyst
- Hypodense brain edema around a SOL
- Left anterior parietal hypodense glioma with marginal enhancement

Hyperdense lesions

- Right thalamic hyperdense recent hematoma with intraventricular extension
- Bilateral hyperdense basal ganglia calcifications

Mass effect: 3 grades
- Effacement of the cortical sulci
- Compression of the ventricle
- Contralateral shift of the midline structures

NCCT of a large right sided subacute subdural hematoma showing all grades of mass effect in the form of effacement of the cortical sulci, marked compression of the right lateral ventricle with contralateral shift of the midline structures to the left side
- Cytotoxic: around acute infarction and hemorrhage
- Vasogenic: around SOL (tumors, abscesses,...)

Vasogenic edema: 3 grades
- Grade I: 2 cm around the lesion
- Grade II: more than 2 cm but less than ½ the cerebral hemisphere
- Grade III: more than ½ the cerebral hemisphere
Sites of intracranial hemorrhage

- Epidural [2]
- Subdural [3]
- Subarachnoid [4]
- Intra-cerebral [5]
- Intra-ventricular [6]

As a general rule

- Acute hematoma (Hyperdense)
- Subacute hematoma (Isodense)
- Chronic hematoma (Hypodense)

CT localization of the site of hemorrhage

Extra axial hematoma = blood extending along the inner skull table = hemorrhage outside the brain parenchyma, being either
- Extra axial hemorrhage (epidural or subdural)
- Subarachnoid hemorrhage

Intra axial hematoma = hemorrhage inside the brain parenchyma

The CSF appears normally hypodense in the cortical sulci and basal cisterns. If the CSF spaces appeared hyperdense on non enhanced CT images (as seen in the scan on the right side), then subarachnoid hemorrhage is diagnosed. This hemorrhage may also extend inside the ventricles.
Extraaxial hemorrhage [epidural or subdural]
- Blood extending along the inner aspect of the calverial bones
- Look to the inner margin of the hematoma
  - Convex inner margin = Epidermal hematoma
  - Concave inner margin = subdural hematoma

Subdural hematoma
- Concave inner margin
- Do not cross midline
- Can be acute, sub acute or chronic

Epidural hematoma
- Convex inner margin
- Can cross midline
- Almost always acute

Classic appearance of a right parietal acute epidural hamartoma extending along the inner skull table with convex inner margin. Note the mass effect on the right lateral ventricle with contralateral midline shift
**Subdural Hematoma**
- Concave inner margin
- Can be acute, subacute or chronic
- Usually seen in elderly patient
- History of minor trauma
- Can occur in the interhemispheric fissure

CT appearance of subdural hematoma in its 3 phases. The left CT image shows the hyperdense acute hematoma on the left side. The middle image shows the relatively isodense subacute hematoma on the right side. The image on the right shows the hypodense chronic hematoma on the right side. In all cases the mass effect is evident on the ventricles and sulci.

**Intracerebral Hematoma**

NCCT of a recent intracerebral hematoma appearing as an oval shaped hyperdense area in the left frontotemporal region surrounded by a rim of hypodense brain edema with consequent mass effect on the left lateral ventricle and contralateral midline shift. No intraventricular extension.

NCCT of a hemorrhagic brain contusion in the right parietal region appearing as an ill-defined area of mixed hypo and hyperdensities with a rim of perifocal edema around. Depressed fracture of the posterior parietal bone is seen overlying the lesion.
**Intracerebral hematoma**

Being adjacent to the ventricle, intracerebral hematoma may or may not extend into the ventricle regardless the size of the lesion and the patient’s age.

![Image of intracerebral hematoma](image1)

NCCT of a right thalamic recent intracerebral hematoma appearing as a well defined hyperdense area in the thalamus surrounded by a hypodense zone of edema with intraventricular extension into the frontal horn of the right lateral ventricle as well as both occipital horns.

**Follow up of intracranial hematoma**

- Epidural hematoma is almost always acute due to severe symptoms as it occurs in a tight space. Patients are rapidly evaluated by CT and evacuation is done on emergency basis.

![Image of epidural hematoma](image2)

Classic CT appearance of acute left parietooccipital epidural hematoma with mass effect on the right lateral ventricle.
**Subdural hematoma**

Can be acute, sub acute or chronic due to minor symptoms as it occurs in a wide space. Patients are evaluated by CT and evacuation is done usually in the chronic stage.

***NB*** All types of subdural hematoma should have a mass effect which depends basically on the hematoma size.

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Other CT appearances of subacute subdural hematoma

***NB*** Hemorrhage in a tumor may simulate the simple intracerebral hemorrhage. Differentiation depends on the edema around the lesion and the shadow of the SOL containing hemorrhagic foci.
**Haemorrhagic tumors**

- Deposits 38%
- Gliomas 35%
- Meningiomas 14%
- Adenomas 9%
- Neuromas 2%

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**Intraventricular hemorrhage** has two main causes:
- Intracerebral hematoma extending into the ventricles
- Subarachnoid hemorrhage refluxing into the ventricles

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**NCCT of a recent left frontotemporal intracerebral hematoma showing a hyperdense area surrounded by a rim of perifocal edema**

**NCCT of a left temporooccipital hemorrhagic SOL showing an ill-defined mass with heterogeneous densities surrounded by vasogenic finger-like edema hypodensity**

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**NCCT of subarachnoid hemorrhage showing the hyperdense fresh blood in the sylvian and interhemispheric fissures with intraventricular extension into the occipital horns**

**NCCT of a recent left temporal recent hematoma showing a hyperdense lesion in the region of the caudate and centiform nuclei with intraventricular extension into the left occipital horn**
Infarction
• Is a hypo dense lesion
• Is not a SOL
• Acute, Subacute or chronic types
• Has a vascular territory
• Has a cortical distribution when it is large

NCCT of a large acute left fronto-temporoparietal infarction appearing as a large hypodense area at cortical and subcortical distribution. The left lateral ventricle is markedly compressed with contralateral midline shift

How to know infarction phase ?!
• Acute infarction is associated with edema causing mass effect on the ventricle and sulci
• Chronic information is associated with volume loss with compensatory dilatation of the adjacent ventricle and sulci
• Subacute infarction is not associated with edema or volume loss, so it has no effect on the adjacent ventricle

Right temporal chronic infarction with compensatory dilatation of the right lateral ventricle
Left fronto-parieto-occipital subacute infarction with no effects on the related ventricle
**Sub acute infarction**
Is a hypodense lesion with no edema nor volume loss

Right fronto-temporooccipital acute infarction with ventricular compression and midline shift

Right parietooccipital subacute infarction appearing as a hypodense lesion of cortical and subcortical distribution with no effect on the adjacent ventricle

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**Chronic infarction**
Loss of volume (gliosis)→ negative mass effect on the ventricle and sulci [Evaccu dilatation]. When the liquefied dead brain tissue is continuous with the ventricular lumen, this is called porencephaly

Left occipital chronic infarction with volume loss and evacu dilatation of the occipital horn of the left lateral ventricle being continuous with the infarcted area denoting porencephaly
Infarction in evolution
The period between vessel occlusion and the appearance of infarction is called infarction in evolution.
The maximum time for an infarction to appear in the CT scan is 72 hours after vessel occlusion.

Male patient, 67 years old presented with right sided hemiplegia, urgent NCCT done within 2 hours of onset showed almost normal findings. Follow up NCCT done 24 hours later showed a large left deep temporal infarct with mass effect on the ventricle.

Infarction follow up

Male patient, 51 years old presented by acute right hemiparesis. Urgent NCCT done on the same day showed subtle hypodensity in the left deep temporal region with minimal mass effect on the ventricle. Follow up 2 days later showed a well established infarction with mass effect. Another follow up done 3 weeks later showed the effect of volume loss on the ventricle.
**Hemorrhagic infarction**
Infarction hypodensity with hyperdense hemorrhagic foci inside. It's two main causes are:
- Venous thrombosis
- Arterial embolism

NCCT of right frontotemporal hemorrhagic infarction showing a large hypodense area of cortical and subcortical distribution with a small internal hyperdense area of fresh blood seen in its medial aspect. Marked mass effect on the ventricle is seen.

**Lacunar infarction**
- Infarction that is smaller than 1cm
- Multiple lacunar infarcts → subcortical arteriosclerotic encephalopathy

NCCT of a right thalamic lacunar infarction showing a small hypodense focus in the anterior part of the thalamus with no mass effect.
Subcortical arteriosclerotic encephalopathy
- White matter ischemic changes → diffuse hypo density
- Usually seen in hypertensive and diabetic patients

Subcortical arteriosclerotic encephalopathy appearing as diffuse hypodensity of the white matter of both hemispheres (left image) compared to the normal white matter (right image)