Cerebral Hemorrhage: MRI Findings
Cerebral Hemorrhage: MRI Characteristics

Appearance on MRI is variable depending on:

- Field strength of the magnet
- Whether the image is T1 or T2 weighted
- Time course of the ICH
  - Hyperacute < 24 hours
  - Acute 1-3 days
  - Subacute
    - Early > 3 Days
    - Late > 7 Days
  - Chronic > 14 Days
Hemoglobin Changes Following Cerebral Hemorrhage

Blood in the Hematoma

- Oxyhemoglobin (intracellular) - Immediate
- Deoxyhemoglobin (intracellular) - 1-3 Days
- Methemoglobin (intracellular) - 3+ Days
- Methemoglobin (extracellular) - 7+ Days
- Hemosiderin - 14+ Days
T1 Weighted

Hyperacute (<24 hours) ICH

T2 Weighted
This results in a slightly hypointense signal on T1
And a slightly hyperintense signal on T2.
This pattern is not specific and is seen in many other types of pathology.
Oxyhemoglobin then changes to Deoxyhemoglobin within intact RBCs
This first occurs at the periphery of the ICH
In addition, enough time has passed that vasogenic edema develops around the ICH
The deoxyhemoglobin results in hypointensity on T1.
As well as hypointensity on T2. Because this change starts at the periphery, a dark ring surrounding a white center can be seen.
The vasogenic edema results in hyperintensity on T2 surrounding the ICH.
At the end of the acute stage, the oxyhemoglobin has completely changed to deoxyhemoglobin.
T1 Weighted

Resulting in hypointensity on T1

T2 Weighted

Resulting in hypointensity on T1
And hypointensity on T2
Vasogenic edema surrounding the ICH remains hyperintense on T2.
Subacute early (+ 3 Days) ICH
Deoxyhemoglobin then changes to intracellular methemoglobin.
This results in hyperintensity on T1
Without any significant change on T2, which remains hypointense.
As RBCs are lysed, the methemoglobin becomes extracellular.
The hyperintensity on T1 persists
However on T2, hyperintensity results from extracellular methemoglobin and the surrounding vasogenic edema.
In the chronic stage, hemosiderin in gliotic brain may exist by itself or may surround a small fluid filled cavity.
The hemosiderin is hypointense on T1.
T1 Weighted

And hypointense on T2
Any remaining fluid is hyperintense on T2.
In the absence of any fluid, hemosiderin remains, resulting in a dark signal on both T1 and T2, as a marker of the remote hemorrhage.
<table>
<thead>
<tr>
<th>Stage</th>
<th>Time</th>
<th>Compartment</th>
<th>Hemoglobin</th>
<th>T1 Image</th>
<th>T2 Image</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperacute</td>
<td>&lt;24h</td>
<td>intracellular</td>
<td>oxyhemoglobin</td>
<td>Hypointense</td>
<td>Hyperintense</td>
<td>Oxygen saturated arterial blood.</td>
</tr>
<tr>
<td>Acute</td>
<td>1-3 d</td>
<td>intracellular</td>
<td>deoxyhemoglobin</td>
<td>Hypointense</td>
<td>Hyperintense, surrounded by hyperintense margin</td>
<td>Fresh blood clots and becomes desaturated, with surrounding edema, deoxyhemoglobin starts first at the border, over 24 hours, all hemoglobin turns to deoxyhemoglobin</td>
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<tr>
<td>Subacute</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early</td>
<td>&gt;3 d</td>
<td>intracellular</td>
<td>methemoglobin</td>
<td>Hyperintense</td>
<td>Hyperintense, surrounded by hyperintense margin</td>
<td>Deoxyhemoglobin is converted to methemoglobin. Intracellular methemoglobin results in signal changes during the early subacute stage (day 3-7). After day 7, increasing extracellular methemoglobin is found (high signal on both T1 and T2).</td>
</tr>
<tr>
<td>Late</td>
<td>&gt;7 d</td>
<td>extracellular</td>
<td>methemoglobin</td>
<td>Hyperintense</td>
<td>Hyperintense, surrounded by hyperintense margin</td>
<td></td>
</tr>
<tr>
<td>Chronic</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Rim</td>
<td>&gt;14 d</td>
<td>intracellular</td>
<td>hemosiderin</td>
<td>Hypointense</td>
<td>Hypointense</td>
<td>This stage may be delayed up to 4-6 months. A fluid-filled cavity is found (low signal on T1, high signal on T2) surrounded by hemosiderin stained gliotic brain. Hypointense slit, or hypointense margin surrounding hyperintense fluid cavity</td>
</tr>
<tr>
<td>Center</td>
<td></td>
<td>extracellular</td>
<td>hemichromes</td>
<td>Hypointense</td>
<td>Hyperintense</td>
<td></td>
</tr>
</tbody>
</table>