Differentiating Perihemorrhagic Infarct from Susceptibility Artifact on DWI Images

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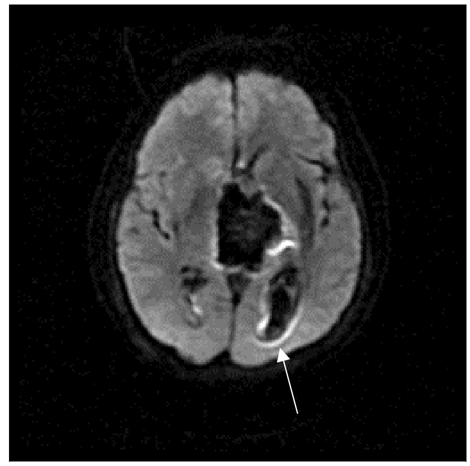
Purpose:
Differentiate between infarction and susceptibility artifact surrounding parenchymal brain hemorrhage.

Materials & Methods:
Diffusion-weighted imaging (DWI) has proven to be extremely sensitive in the detection of acute infarction and has revolutionized stroke diagnosis.[1] However, the use of single-shot echo-planar imaging (EPI) methods for high acquisition speed and minimization of motion artifacts leads to magnetic susceptibility artifacts that can obscure infarctions, especially in the region of the skull base and adjacent to the sinuses.

In the setting of parenchymal hemorrhage a high-intensity rim is often seen around the hemorrhage. The dilemma is often whether this hyperintense rim represents truly infarcted tissue or a signal "pile-up" artifact. The anisotropy of the susceptibility artifact can help differentiate between these two situations. In general, magnetic susceptibility artifacts in single-shot EPI are most prominent in the direction of the phase-encode gradient leading to signal-pile up in this direction. One such source for local magnetic susceptibility changes can be the iron products within a hemorrhage. Therefore, the potential causes of these equivocal hyperintense rims can be differentiated by simply swapping the phase- and frequency-encoded directions and repeating the DWI scan. Regions of susceptibility artifact will change location – i.e. from being most prominent on the left and right of the hemorrhage to being most prominent on the anterior and posterior margins. Regions of truly decreased diffusion due to acute infarction will not change their position.

Fifty-five consecutive patients experiencing stroke-like symptoms underwent routine brain MRI, including two DWI sequences (b=1000s/mm^2), with and without parallel imaging, in which the phase- and frequency-encoded directions were swapped. Two observers evaluated each study for the presence of infarction, first using only one set of DWI images, and then using both sets of DWI images.



Phase-encode in Anterior-Posterior direction

Phase-encode in Right-Left direction

Results:
Nine out of the 55 patients had parenchymal hemorrhage, based upon the formal radiology report. Only 4 of these had hemorrhage with hyperintense rim visible on DWI sequences. With only a single DWI scan available, the observers were unable to differentiate between ischemia and artifact. In these 4 cases the subsequent DWI sequence with exchanged phase- and frequency-encoded directions confirmed that the hyperintensity was due to magnetic susceptibility changes rather than to infarction. (See Figure.)

Conclusion:
The susceptibility artifacts normally associated with diffusion-weighted EPI can interfere with image interpretation in areas where large susceptibility gradients are present, for example adjacent to the sinuses or surrounding a parenchymal brain hemorrhage. The use of parallel imaging helped to reduce (but not eliminate) the severity of signal pile-up surrounding hemorrhage. Unfortunately, it did not by itself reduce the uncertainty in differentiating a rim of infarcted tissue from pile-up artifact. However, since the pile-up artifact is only seen in the phase-encode direction, we recommend repeating the DWI scan (30-40s additional scan time) with swapped phase- and frequency-encode directions to differentiate these two entities.

Acknowledgements:
Acknowledgements: This work was supported in part by the NIH (1R01EB002771-S1), the Center of Advanced MR Technology at Stanford (P41RR09784), Lucas Foundation, and Oak Foundation.

Reference:
1. Roberts TP, Rowley HA. Diffusion weighted magnetic resonance imaging in stroke. *Eur J Radiol.* Mar 2003;45(3):185-194.