Parenchymal CNS hemorrhage: What the Physicist Can Add

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MRI and CT are powerful tools to detect and screen the hemorrhage in the human body. Especially for brain hemorrhage, CT is first choice for acute hemorrhagic stage because of high absorption resulting in high signal [1]. For subacute or chronic hemorrhagic stage, corresponding area in CT image cannot or difficult to show high signal, but MRI image shows high signal sign. Diffusion Weighted Image (DWI) is to be used for detect the hemorrhage in acute stage as high signal intensity [2]. However, it is difficult to discriminate hemorrhage from brain infarct only on DWI-image and therefore CT image and some other information such as perfusion are needed to make final diagnostic decision. In that sense, DWI is not solely diagnostic image for acute hemorrhage.

Contrast changes in both of CT and MRI essentially come from chemical states changing of heme-iron of hemorrhagic blood in the brain. In the subacute and chronic stages, heme-iron changes from deoxyhemoglobin to hemosiderin via methehemoglobin. All of heme-irons are paramagnetic material and therefore show strong T2 shortening effect leading to T2 or T2* weighted imaging (T2, T2*WI) signal depression. This physical background is simple contrast mechanism of such hemorrhagic blood in sucacute or chronic stages.

From physical point of view, phase information of MRI is most sensitive for blood magnetic changing mentioned above. In right-handed coordinate, phase shows negative value for paramagnetic materials such as hemosiderin but positive value for diamagnetic materials such as oxygenated blood (oxyhemoglobin) [3]. This difference may be quite useful for discrimination between acute and subacute or chronic hemorrhages in the brain. Unlike DWI for infarct, phase information shows negative value (deoxygenation) of vessel blood due to tissue oxygen consumption.

There are several phase imaging techniques such as susceptibility weighted imaging (SWI), phase difference enhanced imaging (PADRE, released as SWIp) and quantitative susceptibility mapping (QSM in many way) [4-6]. SWI is a most famous technique and used to detect blood related diseases in clinical sites. Many papers reports SWI, therefore phase information, is several times more sensitive than T2 or T2*WI in detecting the size, number, volume and distribution of hemorrhage lesions. High

detection ability of phase imaging plays active role in traumatic brain injury (TBI) such as brain contusion, diffuse axonal injury, intracerebral hematoma and so on. These TBIs sometimes show microbleeds which are not visible on conventional T2 or T2*W-images, but SWI can illuminates such microbleeds in high detection rate. Moreover, SWI and the other phase imaging technique can show the microbleeds or hemorrhages related to cerebrovascular diseases like a cerebral amyloid angiopathy relating to Alzheimer's disease and dementia [7].

In this presentation, we will introduce phase imaging techniques so as to detect hemorrhage in the brain parenchyma region and discuss these techniques with the view of realistic clinical application.

References

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