Liver Lesions: Added Value of Diffusion Weighted Imaging

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DWI has potential as a tool for functional evaluation permitting insight into the exchange of fluids in tissue (i.e., exchange between the extracellular extravascular and intracellular compartments) at the microscopic level and this may be particularly beneficial in the assessment of and differentiation between normal and abnormal tissues.

Overview: The aim of this lecture is to review the added value of diffusion in liver imaging. This talk with share technical updates on protocol and optimization of image quality but focus on clinical cases and scenarios as well as review updated literature on the topic.

Technical Issues: eg. parallel imaging, breath hold, free breathing versus respiratory triggered, pre versus post gadolinium, b values, ADC calculation, high field

Lesion Detection: DWI can be used for liver lesion detection. As seen in my experience and supported in the literature, low b-values (< 100 sec/mm^2. black-blood imaging) are most useful for lesion detection whereas higher b-values (e.g. b=500 s/mm^2) are more useful for characterization.

Lesion Characterization: Diffusion can be quantified by calculating ADC. At least two images are required: one without application of a diffusion gradient and one with application of a pair of diffusion encoding gradient pulses. ADC calculation is based on the negative logarithm of the ratio of signal intensity of the 2 images weighted by the b-value. If one plots signal intensity (SI) vs. b-value, the higher the b-value, the more signal intensity loss. A malignant lesion for example will have a lower ADC or more restricted diffusion and the slope of the curve (SI v b-values) will not be very steep. A benign lesion is expected to have higher ADC or less restricted diffusion and will be depicted by a steeper slope.

The ADC map quantifies diffusion and will yield a numerical value over a region of interest in addition to demonstrating an imaging representation of the calculation which would depict a malignant lesion for example with restricted diffusion as hypointense in signal rather than hyperintense which would be suggestive of a benign lesion. Studies show that DWI can help differentiate between benign and malignant lesions using ADC values but there is considerable overlap.

Predicting/Monitoring Response to Treatment: Several recent studies have investigated if DWI could predict response to therapy in animal models and humans for a variety of tumors. In fact, DWI has been used to estimate necrosis in tumors such as hepatocellular carcinoma following treatment with promising results demonstrating an increase in ADC following treatment (Kamel IR et al. AJR 2003 et al., Chen CY et al. Radiology 2006, Deng J et al. Vasc Interv Radiol 2006, Goshima S et al JMRI 2008, Deng J JMRI 2008).

Diffuse Liver Disease/Fibrosis: Detecting fibrosis/early cirrhosis is critical for directing patient care and determining prognosis. Liver biopsy is usually required for diagnosis, staging of fibrosis and monitoring treatment. Drawbacks of liver biopsy include the needle puncture and its risk of complications, interpretation errors and sampling error. Conventional MRI is limited for detection of early fibrosis. DWI may play a role in diagnosing fibrosis facilitating early diagnosis and perhaps offering an alternative to biopsy for monitoring of disease and following response to treatment.

Summary

While there are technical challenges, DWI is becoming widely available and is certainly feasible to perform in the clinic. Unfortunately at the present time, absolute quantification (ADC measurements) of DWI remains less reliable (poor accuracy and reproducibility) in body imaging in part due to technical issues including susceptibility and motion artifacts but also due to the confounding effect of perfusion on the Diffusion measurement (as opposed to the brain where the low cerebral blood volume limits the perfusion contribution to the Diffusion measurement) particularly at low b values.