Lipid artifact suppression in amide proton transfer (APT) EPI imaging

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Introduction

The chemical exchange process between water protons and amide protons of endogenous mobile proteins has been shown to provide pH, and protein and peptide concentration dependent contrast in pathological states such as ischemic stroke and cancer(1). These can be studied by selectively irradiation the amide protons and measuring the effect on the water line, which was called amide proton transfer imaging. Sensitivity enhancement is achieved through the CEST mechanism (2). For in-vivo animal studies, there are conventional MT and direct saturation effects in addition to the APT process. To remove their effects, data analysis employs an asymmetry analysis of the MT saturation curve (z-spectrum) with respect to the water frequency. Because water frequency is in the middle of amide and lipid resonances, a super-cranial lipid artifact can be observed if the lipid signal is not suppressed equally in the saturation and reference scan. When using fast imaging acquisitions such as EPI, this artifact may overlap with the lesion region and obscure the analysis. We show here that a chemical shift selective refocusing spin echo EPI can suppress the lipid artifact and provide artifact free pH-weighted (pHw) images from rat undergone the middle cerebral arterial occlusion (MCAO) procedure.

Methods

Adult male Wister rats weight 280-320 grams (n = 5) were anesthetized with 5% isoflurane initially and then remained under anesthesia at 2.5% isoflurane. Permanent MCAO preparation was performed by inserting a 4-0 nylon suture into the lumen of Internal Carotid Artery (ICA). Its respiratory status and blood pressure were monitored online. All images were acquired using a 4.7 Bruker Biospec animal imager. The field of view was 3.2x3.2 cm², with an image matrix of 64 by 64, and the slice thickness was 2 mm.

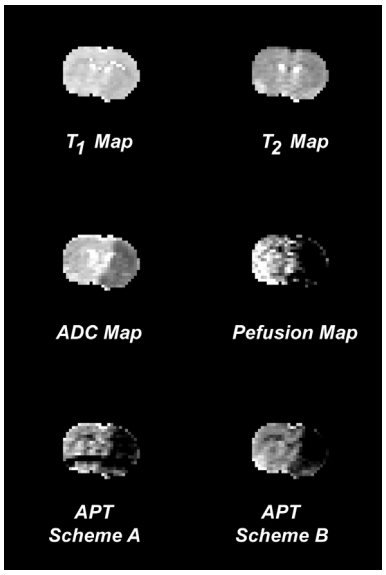

Fig. A

Results and Discussion

Images were acquired one hour after MCAO preparation. Though there is little contrast from relaxation images, the ischemic lesion is prominent on both the diffusion and pHw images, which are in close match with the hypoperfusion region from the perfusion map. A lipid artifact is clearly visible in the pHw EPI image (Scheme A). The artifact arises from better preserved pericranial fat at the 8.3ppm offset with respect to 1.3ppm, where it is directly saturated. APT images are particularly prone to this artifact because the lipid has a "unique" chemical shift that is of equidistant as amide proton from the water resonance but of opposite sign. The asymmetry analysis introduces artifacts due to the unequal fat suppression. Thus in order to obtain an appropriate pH-weighted image, the lipid resonance has to be suppressed equally regardless of the offset of the saturation pulses. Application of a spin echo EPI with a chemical shift selective refocusing pulse (Scheme B) successfully suppressed the lipid artifacts.

Conclusion

We found that an EPI fat artifact occurring in APT images was due to the unequal suppression of the lipid signal by the saturation pulse at frequencies above and below the water. tThe use of a spin echo sequence with a chemical selective refocusing pulse can suppress such artifacts during in-vivo pH imaging. The approach can also be useful for CEST agents that have exchangeable protons in the spectral range of amide protons as well as for general lipid suppression purposes in all organs.

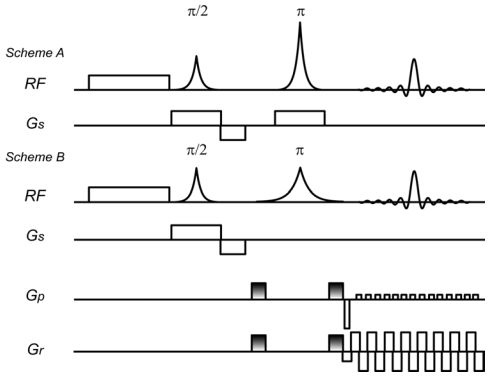

Fig. B

References

1. Zhou J. et al. Nature Med. 2003; 9:1085-1090.
2. Ward KM. et al. J Magn Reson 2000; 143:79-87.