The feasibility of ASL Spinal bone marrow perfusion Imaging with optimized TI

Dong Xing[1], Yunfei Zha[1], Lei Hu[1], Jiao Wang[1], Yuan Lin[1], and Hui Lin[2]

[1]*Department of Radiology, Renmin Hospital of Wuhan University, Wuhan, Hubei, China,* [2]*MR Research, GE Healthcare China, Shanghai, China*

Target Audience: Clinicians and researchers who interested in Musculoskeletal perfusion.

Introduction: Spine is a predilection site for degeneration, metastases, bone marrow infiltrates and other diseases, which would cause serious harm to the health of patients. Arterial spin labeling (ASL) is a technique for quantification of tissue perfusion. This simple and reproducible technique does not requires injection of contrast, which allows the use on children and renal dysfunction patients. Those benefits make ASL a preliminary application in musculoskeletal system. However, ASL has not been applied to the spinal bone marrow lesions in the literature up to date.The purpose of this study is to assess the feasibility of Spinal bone marrow (SBM) ASL perfusion Imaging .

Methods: Forty one healthy volunteers without lumbar and other disease were included. The optimized TI of FAIR spinal bone marrow perfusion experiment was carried out on 14 healthy volunteers on a 3.0 T whole-body MRI scanner, two adjacent vertebral bodies were orderly selected from each volunteer to measure the the change of signal intensity (ΔM) and the SNR of FAIR perfusion MRI with 5 different TIs (800, 1 000, 1 200, 1400, 1600 ms), and the vertebral bodies selected order were determined by the order of the subjects enrolled. Then, FAIR and DCE-MRI were performed back-to-back on the 54 lumbar vertebral bodies from 27 subjects, each vertebral body was selected as a region of interest (ROI) with Functool and Cinetool at AW 4.4 workstation, respectively(**Fig1,2**). The correlation between the blood flow on FAIR (BF_{ASL}) and perfusion-related parameters (K^{trans},K_{ep},V_e) on DCE-MRI was evaluated using the Pearson correlation coefficient.

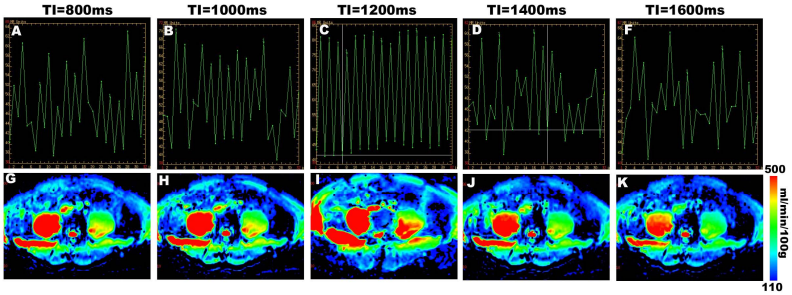

Fig 1: ASL perfusion: The signal intensity - acquisitions curves (A-F) and the perfusion images (G-K) of L2.

Result: With the increment of TI from 800 ms to1600 ms, ΔM and SNR both increased first and then decreased, with the maximum value of both happened at TI approximately equal to 1200ms (**Fig3**). The blood flow on FAIR showed a close correlation with K^{trans}(r=0.646, p <0.001) and K_{ep} (r=0.387, p =0.004), and no correlation with V_e (r = 0.239,p =0.082) was found.

Discussion: The accuracy of BF_{ASL} calculations is dependent on the appropriate selection of TI value, which not only leads to better perfusion image quality, but also has effects of transit time,δt, which is thought to be the major source of error in the quantitative estimate of perfusion due to the improper TI(1-3). Considering the δt differs according to the histology and hemodynamics of the tested tissue, it is hence necessary to have the optimization study on TI. Which TI matches the δt of SBM best is still unknown to us.The correlations of BF_{ASL} to K^{trans} and K_{ep} have different interpretations. The BF_{ASL} means the volume of blood flow per 100g of tissue per minute, while the explanation of K^{trans} depends on the physiologic situation of tissue(4). In high permeability situations, K^{trans} means the blood flow per unit volume of tissue, which is determined by the flow; and in low limited situations, K^{trans} means surface area product between blood plasma and the EES, which is limited by the capillary permeability. As the anatomical basis of bone marrow blood flow is sinusoid, which only have single layer of endothelial cells and has high permeability. In addition to the high permeability of sinusoid, Cho et al.(5) thought when using low-molecular contrast material as the contrast agent, the contrast agent can freely perfuse through the vascular endothelial gaps, the vascular permeability is mostly determined by the blood flow. Thus K^{trans} of SBM equal to the blood flow per unit volume of SBM, and for the same reason, K_{ep} , which represents the permeability from EES to intravascular space, is restricted by the blood flow.

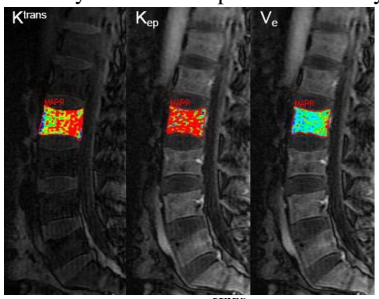

Fig2: DCE-MRI: The K^{trans},K_{ep} and V_e map of L2.

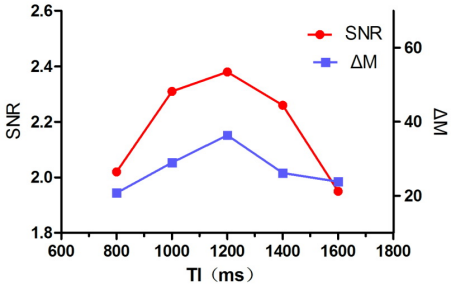

Fig 3: Average SNR and ΔM curves for the ASL images with 5 TIs.

Conclusions: The optimal TI for SBM ASL perfusion image is 1200 ms, which led to the maximum ΔM and good quality perfusion image with higher SNR. And as blood flow measurement on FAIR is reliable and closely related with the parameters of DCE-MRI, FAIR is feasible for measuring SBM blood flow.

References:1. Hendrikse J, et al. Radiology 2004; 233:899-904. 2. Fan L, et al. Eur J Radiol 2009; 70:41-48. 3. Martirosian P, et al. Eur J Nucl Med Mol Imaging 2010; 37 Suppl 1:S52-S64. 4.Tofts PS, et al. J Magn Reson Imaging 1999; 10:223-232. 5. Cho JH, et al. J Magn Reson Imaging 2010; 32:738-744.