Quantitative Perfusion and Permeability Analysis of Animal Brain Using Dual echo DCE-MRI

Y. Yu[1], Q. Jiang[2], H. Wang[3], S. Bao[3], E. M. Haacke[4], and J. Hu[4]

[1]Logging technique research institute, great wall drilling company, China National Petroleum Corporat, Beijing, China, People's Republic of, [2]Department of Neurology, Henry Ford Health Sciences Center, Detroit, MI, United States, [3]Beijing Key Lab of Medical Physics and Engineering, Peking University, Beijing, China, People's Republic of, [4]Department of Radiology, Wayne State University, Detroit, MI, United States

Introduction

The importance of accurate estimation of permeability and perfusion parameters has been long recognized [1-2]. It is well known that the injection of contrast agent (CA) induces changes in both T1 and T2* of tissues. However, permeability is typically estimated using T1-weighted DCE-MRI data without T2* correction, while perfusion is typically estimated using T2*-weighted DCE-MRI data assuming constant T1. The purpose of this project is to investigate the effect of T2* on permeability as well as effect of T1 on perfusion using a new pharmacokinetic model with simultaneously acquired T1- and T2* DCE-MRI data [3].

Materials and methods

A dual gradient echo pulse sequence (Fig.1) was used to simultaneously acquire T1- and T2*- weighted DCE-MRI data on a Bruker 7T animal scanner. The experimental parameters were: TR=60ms and TE1/TE2 = 4.36/8.72 ms. The study has been approved by the participating institute. Permeability parameters were obtained using the following procedure: 1) T1-weighted DCE-MRI for each pixel at each time frame were compensated using corresponding T2* values obtained from dual echo DCE-MRI data; 2) T1(0) value for each pixel before CA injection was estimated using a modified reference region method; 3) the concentration of the CA was calculated using T1-weighted DCE-MRI with T2* compensation and T1(0) obtained in step 2; 4) Permeability parameters were estimated using the extended Toft model [4]. Perfusion parameters were estimated using the following steps: 1) directly calculating T2* values from dual echo DCE-MRI data; 2) Automatically extracting arterial input function (AIF) using FCM technique; 3) measuring regional cerebral blood volume (rCBV) from the first pass area under the CA concentration curves of each pixel and AIF curve; 4) estimating regional cerebral blood flow (rCBF) by singular value decomposition (SVD) approach.

Results

Fig. 2 illustrates typical uptake curves for T1-weighted DCE-MRI with and without T2* correction from tumor and control areas respectively. The average K_{trans} for tumor with T2* correction was nearly two times greater as without T2* correction. In contrast, the difference between average K_{trans} for healthy brain with and without T2* correction was about 20%. Similar results were observed for rCBV with and without considering T1 effects.

Discussion

The preliminary results demonstrate that 1) T2* has great effect on the estimation of permeability parameters, 2) T1 has great effects on the estimation of perfusion parameters, and 3) both the T1 and T2* effects are much greater in tumors when compared to healthy brain tissue. This observation is consistent with the common knowledge that CA concentration is typically much higher in tumors than in healthy tissue because of incomplete and leaky tumor vasculature.

Conclusion

T1- and T2*- weighted DCE-MRI can be obtained simultaneously using a simple dual gradient echo sequence with one admission of contrast agent. More importantly, simultaneously acquired T1- and T2*-weighted DCE-MRI data can be used to improve the estimation accuracy of permeability and perfusion parameters.

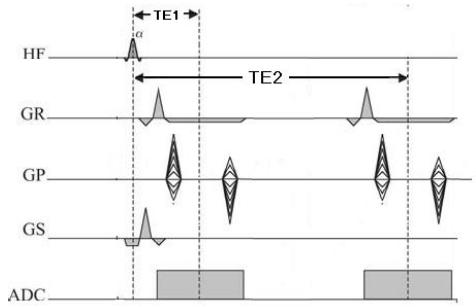
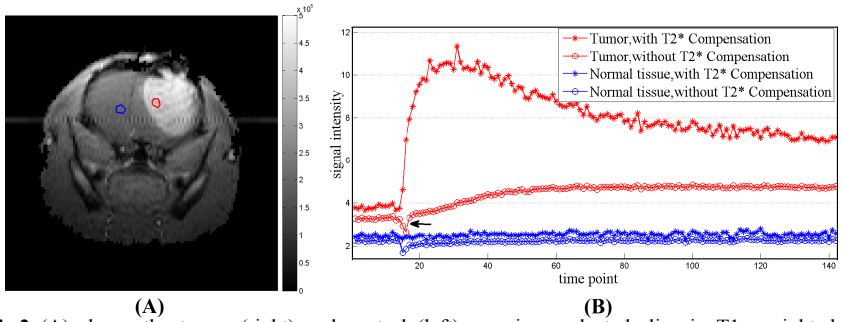


Fig.1 Dual gradient echo pulse sequence used to simultaneously acquire T1- and T2*- weighted DCE-MRI data.



(A) **(B)**

Fig.2 (A) shows the tumor (right) and control (left) area in a selected slice in T1- weighted DCE-MR image; (B) shows the typical uptake curves for T1-weighted DCE-MRI with and without T2* correction from tumor and control areas respectively.

Reference

[1] Kvistad KA et al. Radiology 2000;216(2):545-553. [2] Vonken EP et al. MRM 2000;43(6):820-827. [3] Quarles CC et al. PMB 2009;54(19):5749-5766. [4] Tofts PS et al. JMRI 1999;10(3):223-232.