

Robust Assessment of the Renal Physiological Response Using Breath-Hold Whole Kidney T2 Measurement

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Introduction

Renal function and metabolic activities can be directly related to the blood perfusion and tissue oxygenation that are measurable using MRI. It has been demonstrated previously blood oxygenation level-dependent (BOLD) MRI can be used to noninvasively evaluate intra-renal oxygenation levels based on the spin dephasing effect of paramagnetic deoxyhemoglobin [1-3] by T2* weighted gradient echo method. Here we report that using widely available T2 weighted GRASE method intra-renal functional response to the intravenous infusion of amino acid can be readily assessed via multi-slice and multi-echo T2 measurement.

Materials and Methods:

Subjects Nine healthy volunteers (5 male and 4 female, age 25-45) without history of renal disorders participated in the study after obtaining informed consent. They were asked to abstain from food and caffeine overnight prior to the study, but water ad libitum.

Imaging T2 weighted images were collected on a 1.5T (Philips Intera) using 6-channel phased surface coil array with SENSE parallel imaging applied (SENSE factor of 4). For T2 measurement, a multi-slice and multi-TE GRASE sequence was used with TR=800ms, NSA=2, EPI factor of 5, rectangular FOV of 340 x 270 mm and image matrix of 256². Images from 8 TEs were obtained in a single breath-hold (~22 seconds). Typically, 10 axial slices with the thickness of 6 mm and gap of 4 mm were used to cover both kidney volumes. The slices were placed based on the coronal scout breath-hold images.

Amino Acid (AA) Infusion A 20% balanced salt amino acid solution (Baxter, Deerfield, IL) was infused over 60 min. during T2 imaging. It has been demonstrated previously in both animal and human experiments that ingested or intravenously infused amino acids will lead to reproducible elevated renal function, with increased renal blood flow and filtration, representing a physiological challenge inducing a predictable renal response. The baseline T2 for each subject was measured three times before AA infusion and was repeated within 7 days after AA experiments. Acute T2 response to AA infusion then was measured repeatedly at 5 or 10-minute intervals during the AA transfusion.

Data Analysis T2 value was calculated at the voxel basis using the non-linear fitting of a single exponential function of the signal intensity at the different echo times (TE). T2 maps were generated for each subject and for each time point of AA infusion. Twenty regions of interest (ROIs) were selected from the cortex or medulla from 2-4 ROIs per slice per cortex, and then per medulla, of both kidneys to calculate averaged T2 for the defined anatomic area. The statistical significance of differences between baseline and AA infusion in T2 was assessed by means of a two-tailed paired Student's t-test.

Results and Discussion

Increased T2 was observed in the renal cortex, but not the medulla, of all subjects after intravenous infusion of the amino acid solution, consistent with acute functional response of kidney to the metabolic challenge. The mean difference of pre- and post amino acid infusion was 9.6% (p=0.0006), while the measurement of baseline T2 within the subject showed good reproducibility (averaged mean deviation: 1.2%, p=0.34). In addition, the time-dependent T2 change was recorded in the renal cortex in all subjects during the course of the infusion of the amino acid (Fig 1), demonstrating the robust detection of renal functional response using this method. The authors believe this is the first demonstration of the BOLD effect in response to an amino acid challenge. Furthermore, the approach of using T2 weighted GRASE method allows acquiring multi-TE T2 images in multi-slice fashion to cover the entire kidney volume in a breath hold acquisition. This sequence should be readily available on most scanners. Other suggested benefits of the T2 method described in this report include decreased artifacts from undesirable susceptibility affects such as from adjacent bowel gas.

References

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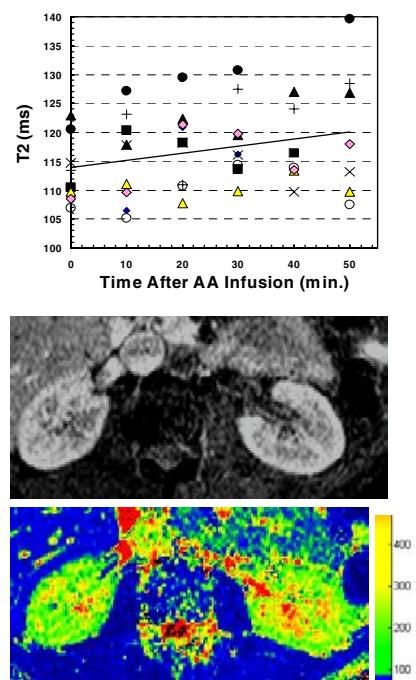


Figure 1. T2 increase was observed in all subjects during the course of AA infusion (top). A T2 weighted kidney image (1st TE) from the image series showed clearly defined renal cortex and medullar (middle) with T2 maps calculated from the T2 image series (bottom).