

Target audience: Investigators and clinicians interested in performing MR renography with dynamic contrast enhanced sequences

Introduction: MR renography with a low dose of Gd contrast can be used to measure glomerular filtration rate [1]. For dynamic image acquisition, a T1-weighted saturation-recovery (SR) sequence can be used [2]. The image readout is performed following a so-called inversion time (TI) after the saturation. The acquired signal magnitude reflects T1 value of kidney tissue at the time of measurement, and thus the gadolinium concentration. Quantitative analysis of the dynamic data also requires an arterial input function (AIF), obtained from images of the abdominal aorta. The selection of TI deserves some consideration, particularly for the accuracy of AIF. During the first pass of the contrast bolus, the relatively high Gd concentration leads to fast T1 recovery, so the signal acquired with a long TI may be saturated, no longer reflecting the true Gd concentration; on the other hand, a short TI could result in signal with low signal to noise ratio (SNR). This problem is less severe for kidney tissue because Gd concentration in the tissue is much lower than the first-pass peak of AIF.

In this study, we compared two TI values for acquiring SR images of abdominal aorta, and the resulting GFR estimates were compared to reference values measured with ^{99m}Tc-DTPA clearance.

Materials and methods:

This HIPAA-compliant study was approved by our IRB board, and written informed consent was obtained from all subjects. Sixteen human subjects (10 males, 6 females, age 40-81 yrs, weight 72.1-120.4 kg) were included. The MRI was performed at 3.0T scanner (Tim Trio, Siemens) using a 2D SR-Turbo-Flash sequence, with parameter values: TR per slice 519.14 ms, TE 1.15 ms, flip angle 15°, bandwidth 1015 Hz/pixel, matrix 160x176, FOV 454x499 mm, acquisition time 1.6 s, 142 repetitions. Three different slices were imaged, including one coronal slice through the aorta with TI = 100 ms, one oblique coronal slice through the kidneys with TI = 300 ms, and one oblique axial slice through the kidneys with TI = 300 ms. About 15 sec after the start of imaging, 3 ml of gadoteridol was injected at 2 ml/sec, followed by a 20-ml saline flush. Proton density imaging with 2D turbo FLASH and long TR (7s) was performed immediately after the dynamic imaging. On the same day as the MRI scan, reference GFR was derived from ^{99m}Tc-DTPA clearance. We used an approach published in ref [2].

For data analysis, images were cropped, registered and then segmented for each kidney. Averaged signals for cortex and medulla were converted to T1 values and then to Gd concentration [2]. To estimate AIF, an aortic ROI was drawn in two slices, the aortic coronal slice with TI of 100 ms and the kidney axial slice with TI of 300 ms. Using each of these two AIFs, we fitted the tissue concentration vs time curves with a whole-kidney model [2,3] to obtain GFR estimates. GFR values for the right and the left kidneys were summed to get a global GFR value (termed MR-GFR), to compare with reference values (termed Nucs GFR). The correlation coefficient (R) between MR-GFR and Nucs GFR was computed.

Results: Reference Nucs GFR for the subjects were 95.8±32.2 ml/min. MR-GFR estimated with AIF of TI 100 ms were 62.4±22.5 ml/min, and with AIF of TI 300 ms were 67.4±22.1 ml/min. Correlation coefficient between Nucs MRI and MRI GFR with AIF of TI 100 ms was 0.603, and with AIF of TI 300 ms was 0.920 (Fig. 1). Fig. 2 demonstrates the estimated signal

using a saturation recovery sequence for blood with T1 of 150 ms compared to T1 1500 ms across a range of TI values.

Discussion: We compared TI values of 100 ms and 300 ms in saturation recovery imaging for renal GFR measurements. For the AIF, accurate estimates of the baseline T1 value are often used in computing post-contrast Gd concentration. Therefore, the potential error in baseline T1 would be propagated to all concentration estimates, including the high values. Hence, while short TI has the theoretical advantage of avoiding signal saturation when Gd concentration is high, we observed that the disadvantages of inaccurate Gd concentration estimates at baseline outweigh this benefit. With a longer TI such as 300 ms, we obtain more accurate T1 estimation at baseline and for all points in the AIF tail and also show that the agreement between MR-GFR values and reference radionuclide GFR is higher.

In conclusion, for DCE MRI of the kidney and other tissues, if a saturation recovery sequence is used and AIF is required for data analysis, we suggest using relatively long inversion time to avoid the accumulation of AIF error in the estimated parameters. Specific inversion time values depend on the gadolinium dosage injected.

References: [1] Lee et al AJP-Renal Physiol 292:F1548. [2] Vivier et al Radiology 259(2):462. [3] Koh et al. Phys Med Biol 51(11):2857.

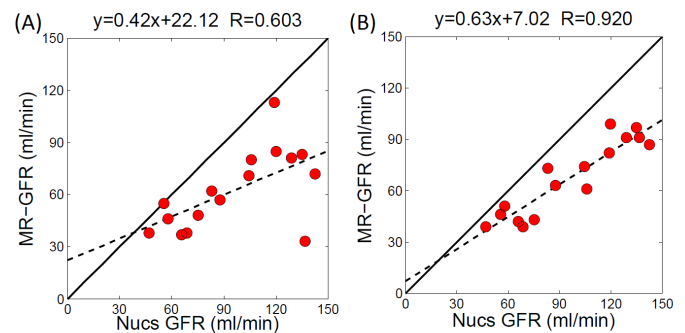


Fig. 1: Correlation plots between Nucs GFR and MR-GFR. (A) AIF from SR images acquired at TI 100 ms; (B) TI 300 ms.

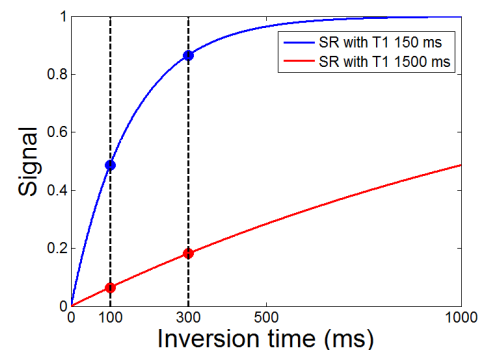


Fig. 2 Saturation recovery with different T1 values. T1 of 150 ms represents typical shortest T1 of blood in our data, while T1 of 1500 ms represents baseline blood T1. Signal acquired at TI of 100 ms is only 5% of maximal signal level.