Measurement Accuracy of a Gadolinium Enhanced Magnetic Resonance Imaging Technique for the Measurement of Kidney Glomerular Filtration

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Introduction

Glomerular filtration rate (GFR) can be determined by MRI perfusion-filtration techniques using rapid volumetric perfusion imaging after administration of a filtered gadolinium-chelate. Several methods have been employed. We have been developing a methodology based on a 3-compartment kinetic model that accounts for the renal vascular, interstitial, and filtered compartments. We have shown, using this modeling, that individual renal blood flow can be determined. There is growing evidence to show these methods capable of measuring GFR with reasonable accuracy, although there remains a need to further grow this body of evidence. Elective kidney transplant donor assessment includes kidney function evaluation and 24 hour creatinine clearance (CrCl) is the standard method used currently. These patients represent an excellent uniform potential population for further investigation of MRI-based GFR measurement techniques.

Purpose

The purpose of this investigation is to determine the capacity of a 3-compartment kinetic renal filtration model to measure GFR as compared to CrCl in a renal donor population.

Methods

This investigation was HIPPA compliant and approved by our internal review board and all patients provided an informed consent. ***GFR measurement*:** CrCl was used to determine GFR in 20 kidney donors age 20 to 66. Twenty four hour urine collection was obtained within 2 days of the MRI. A single draw of serum Creatinine was performed. CrCl was calculated for urine creatinine concentration (Ucr), urine flow rate V and plasma creatinine concentration Pcr. Ccr= (Ucr x V)/Pcr.
Prior to the imaging, the patients were hydrated with 500 ml of water 1 hour prior to the exam. ***MRI acquisition***: Imaging was performed using a 1.5 tesla magnet (Siemens) and phased array surface coils. Contrast (Prohance, Berlex, NJ) was infused at a dose of 0.05mmol/kg diluted to 60ml and infused at a rate of 2ml/sec for a total infusion time of 30 seconds. Dynamic acquisition was performed using a 3D gradient echo, fat sat, coronal, 25 deg flip,3mm slice thickness, 32 slices, 420 FOV, IPAT=2, 192 matrix (60% phase resolution), 1300Hz/px bandwidth, per image time=2.0s x 140 dynamic images, TR=2ms and TE=1ms. Images were acquired with the patient breathing freely**. *Image analysis:*** The dicom files were converted to the Analyze NIFTI file format and imported into Analyze v6.0 (Mayo Clinic MN). Regions of interest were created for both kidneys and the aorta. The bulk renal signal results along with the segmented kidney volumes were input into a three compartment kinetic modeling program that was developed at our center, which optimally fits 4 physiological variables (including GFR) to each kidney using a 3-compartment kinetic model: vascular, interstitial, and filtered compartments. The model assumes uniform Gd distribution in the plasma, unidirectional kinetics into the tubules, and free diffusion in/out of the interstitial space. This model has been described previously (1,2). **Statistics**: Bland-Altman analysis was used to compare MRI GFR and CrCl measurements.

Results

A Bland Altman plot (Figure1) shows a mean difference of -0.3 between the MR GFR and CrCl with limits of agreement (-21.7, 22.2). The Pearson correlation coefficient between the two is 0.76 with a confidence interval equal to (0.48,0.90), p value 0.0001. (test if correlation =0). The two methods are highly correlated (0.76) and have a very small difference between the means.

Conclusion

Statistical analysis show that our 3-compartment modeling of the kidney GFR using contrast enhanced MRI results in measures of GFR that could be interchangeable with CrCl.

References

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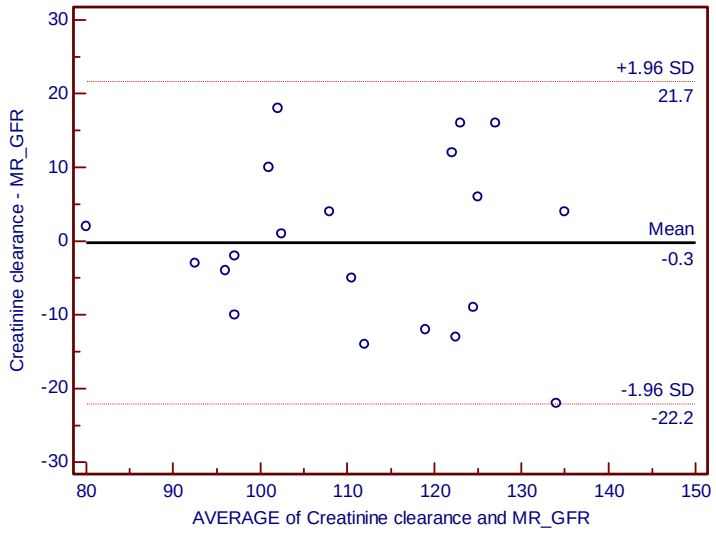

Figure 1. Bland Altman Plot