

# Variation in GFR estimates derived from DCE-MRI renography studies in the presence of reduced Signal to Noise Ratio

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## Introduction:

Dynamic contrast enhanced magnetic resonance (DCE-MR) renography has developed rapidly over the past decade with the aim of providing a single diagnostic framework that can accurately assess kidney function. However, DCE-MR renography has not yet been successful in providing an accurate and robust kidney assessment technique [1] due to various confounding factors, ranging from optimization of data acquisition parameters to the data post-processing steps. Whilst some of these confounding factors have been well recognized in the published literature, there is little knowledge on the robustness of DCE-MR renography in the presence of reduced renal function. Renal impairment diminishes the kidney's extraction capacity of contrast agents (such as Gd-DTPA) from the bloodstream, resulting in subsequent reduction of the signal-to-noise ratio (SNR) in the DCE-MR images and noisier MR renography curves. The aim of this work is to evaluate the accuracy and robustness of DCE-MRI derived glomerular filtration rates (GFR) in the presence of synthetic SNR variation in DCE-MRI renal data series. To our knowledge, no similar work has been published or presented in the literature to date.

## Methods:

The SNR analysis is based on the systematic degradation of the DCE-MR renal data by adding variable noise levels to the images and renal curves. 10 normal subjects were imaged at baseline and after injection of 0.05 mmole/kg of Gd-DTPA, on a Siemens 1.5T Avanto scanner, using a TIM 32 channel body phased array coil and a spoiled gradient echo 3D sequence with TR=1.6ms, TE=0.6ms, FA=17 degrees. 18 contiguous 7.5mm slices were collected every 2.5s, with in-plane resolution of 3.1 x 3.1mm, covering both kidneys.

The DCE-MRI renal data sets were statistically degraded by adding normally-distributed synthetic noise fields of zero mean and variable standard deviations, ( $\sigma_s=2,4,6,8,10$ ). For each particular standard deviation, the renal data were degraded by ten statistically independent noise realisations and evaluated in order to observe the variation in DCE-MRI estimated GFR values that might be observed in-vivo when the SNR is decreased due to reduced contrast agent uptake. Each noise field was convolved with the point spread function (PSF) of the 3D gradient echo pulse-sequence [2] to produce the characteristic correlated noise that is also present in the actual renal data. Degraded time intensity curves were then derived from a renal parenchymal region of interest (ROI) and quantified using the Tofts renal model [3] in order to estimate the kidneys' GFRs. As an alternative approach to the spatial data degradation (described above), temporal data were directly degraded by adding normally-distributed univariate noise samples of zero mean and various standard deviations ( $\sigma_t=2,4,6,8,10$ ). The temporal data were also degraded 10 times for each degradation level in order to observe the variation in the estimated GFR values that might be observed in-vivo when the SNR is decreased due to reduced uptake of the contrast agent.

## Results:

$K^{trans}$ , a rate constant equating to GFR per unit volume of kidney, demonstrated significant variation of >10% for  $\sigma_s > 4$  in the case of spatially degraded data and for  $\sigma_t > 2$  in the temporally degraded data. This corresponded to a SNR variation of about 0.05 - 0.1 compared to the original data.

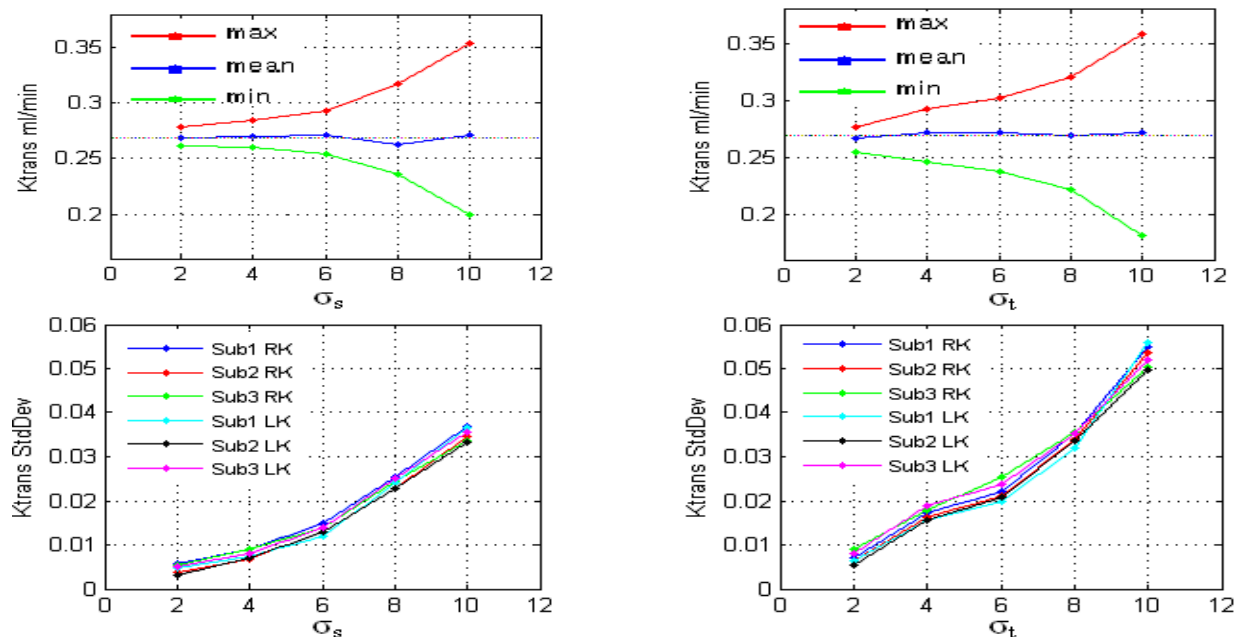


Fig. 1: Spatially degraded data: Top-left:  $K^{trans}$  values are plotted against the standard deviations of the additive noise fields ( $\sigma_s$ ) in spatially degraded data for one kidney where only minimum, maximum and mean values of 10 estimates are shown. Bottom-left: the dispersions in the  $K^{trans}$  values are shown for 6 kidneys (3 subjects) where consistency of the results is evident. Temporally degraded data: Top-right: an exemplar plot of one kidney  $K^{trans}$  estimates where the temporal data are degraded directly. Bottom-right: the dispersions of the  $K^{trans}$  values against the additive noise standard deviation ( $\sigma_t$ ) are shown for 6 kidneys.

## Discussion and Conclusions:

The SNR analysis methodology was developed by means of systematic degradation of the renal data in order to evaluate the variation in GFR estimates when SNR drops due to reduced renal function (resulting in reduced renal filtration of Gd-DTPA and lower image SNR compared to normally functioning kidneys). Our results suggest substantial variations in  $K^{trans}$  (i.e. >10%) for relatively small changes of the SNR in the data (i.e.  $\sim 0.05 - 0.1$ ).

**References:** 1. Mendichovszky I, et al. JMIR 27:925-931, 2008. 2. Rodriguez D et al. EJR 75 (2010) 221-229. 3. Tofts PS, et al. Proc Intl Soc Mag Reson Med, 18th annual meeting, Stockholm, 2010; 326.