

Estimation of GFR in the infant kidney

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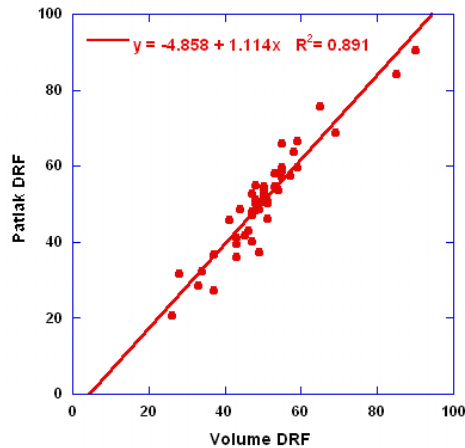
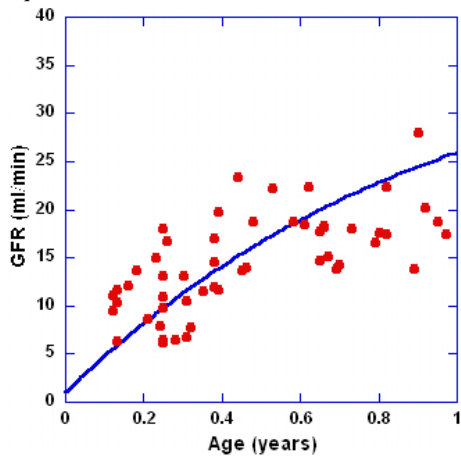
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Introduction

The ability of MRI to provide excellent anatomical information on both the kidneys and urinary tract is well known, however, in the absence of additional functional information it is difficult to justify performing MRI over other modalities. We have been developing a protocol for pediatric MR urography which combines anatomical and functional information. We have previously derived the differential renal function (DRF) based on the parenchymal volume measured post-contrast and shown that this is well correlated with the DRF measured using nuclear medicine (1,2). Subsequently, we showed that the time required for the contrast agent to transit through the kidneys as measured using MRI is well correlated with the $T_{1/2}$ parameter widely used to characterise nuclear medicine studies (3). In this abstract we describe our experience using dynamic, contrast enhanced, MRI to estimate GFR in pediatric patients aged below one year of age.

Materials and methods

All studies were performed on a 1.5T Siemens Symphony scanner. The patient preparation and the MRI sequences used to depict the anatomy have been described previously (1-3), all patients were sedated using our department's standard sedation procedures. The dynamic sequence consisted of a 3D, fat saturated VIBE sequence, the typical FOV and slice thickness were 240mm and 2 mm respectively. A total of 36 slices were acquired for each volume with the outer 3 slices on each side being discarded to limit slice profile effects. Other imaging parameters included an in-plane matrix of 256 x 197, TR/TE = 3.5/1.5 msec., flip angle = 30° and a parallel imaging factor of 2, the time required to acquire each volume was 9 seconds. The first 13 volumes were acquired contiguously, subsequently 6, 11 and then 51 second intervals were inserted between scans such that 28 volumes covered a total of 10 minutes. 2 ml of Magnevist was injected at a rate of 0.2 ml/sec via a power injector starting at the beginning of the fourth dynamic image. The resulting dynamic data set was processed off-line using Analyze 6.0. First of all the images were interpolated to isotropic resolution, filtered using a 3D median filter. For the segmentation of the descending aorta the volume best depicting the first passage of the contrast agent was used while for the kidneys the last volume prior to the appearance of contrast in the collecting system was used for the segmentation of the parenchymal volume. The segmentation was performed using a semi-automatic method based on intensity thresholds, morphological erosion and dilation and region growing. The resulting 'masks' allowed signal intensity versus time curves to be generated and, in the case of the kidneys, also provided an estimate of the parenchymal volume of the kidney. The resulting signal versus time curves were processed to yield relative signal versus time curves where the relative signal at time point t is given by $(S_t - S_0)/S_0$ where S_0 is the mean baseline signal. Previous phantom studies have indicated that for the flip angle of 30° used in these studies the relationship between relative signal and contrast agent concentration is linear for concentrations up to approx. 1mmol/L (4). On the basis of the relative signal levels observed in the aorta and parenchyma the concentration did not exceed this level in any of these regions. To calculate the GFR a Rutland-Patlak technique (5) was used. In these patients there was no systematic measurement of the GFR using a reference technique, thus in order to assess the accuracy of the results the data was compared with the data recently published by Wahl et al which derived best fits to the data from studies by multiple authors (6).



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Results

Figure 1 compares the best fit curve from the data of Wahl et al (6) with the total GFR (i.e. the sum of both kidneys) for 54 patients. The age dependent trend in the increase of the GFR with age in our data initially follows that of the fitted data derived by Wahl et al but tends to be lower at ages above 7-8 months. There is considerable scatter in our data, however, as all of the patients were referred due to suspected renal/urinary tract problems, including obstructed kidneys and single kidneys, a reasonable amount of variation in the GFR is to be expected. Figure 2 compares the DRF of the left kidney of all the patients except those with single kidneys calculated using the GFR of the left and right kidneys with that calculated using the parenchymal volume. The agreement between the two methods is very good for DRF in the normal range but with a tendency for the Patlak DRF to be lower than the volumetric DRF for smaller kidneys,

with this tendency is reversed for larger kidneys, which may reflect changes in the concentrating ability of the medulla.

Conclusion

This preliminary study of GFR values derived using dynamic, contrast enhanced MRI in a clinical setting implies that for very young pediatric patients, who constitute the bulk of our patients, the method produces age appropriate results. However, a full validation will require a comparison with an accepted reference method (such as inulin clearance). At present, the generation of the Patlak plot and a plot of relative signal intensity against time for the kidneys and aorta requires 15-20 minutes. Using dedicated software should permit this time to be reduced to approx. 5 minutes. The major source of error appears to be the definition of the aorta and further work is required to make this part of the processing less user dependent. The volume of the kidney appears to be a fairly robust surrogate for the DRF as calculated using the GFR.

References

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