DTI at different b-values in kidneys in children with unilateral pylonephritis

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Introduction

DTI can evaluate functionality and morphology of kidneys because of their radially oriented tubular structures. Perfusion probably contributes to apparent diffusion in particular at low b-values [1]. The aim of this study was to evaluate the ability of DTI to assess renal damage in patients with unilateral chronic pyelonephritis induced by vesicoureteral reflux, a condition that damages medulla and successively glomeruli in the cortex.

Methods

The study population consisted in 12 patients (7 males; mean age: 10 years, range 6-17 years) affected by unilateral pyelonephritis assessed by renal scintigraphy (Tc^{99}-DMSA). Examinations were performed with a 1.5 T Signa Horizon LX whole-body scanner (General Electric Medical Systems). RF excitation was performed using the body coil and reception using a 8-element phased-array coil designed for adult cardiac imaging. T_2w respiratory triggered SS-FSE and T_1w FSPGR in-phase axial images were acquired. DTI was performed using axial fat-saturated single-shot DTI-EP images. Diffusion gradients were oriented along 6 directions, b-values of 0, 100, 300, 600, 800 s/mm^2 were used; imaging parameters were: slice thickness 6 mm and gap 1 mm, TR 4000 ms, TE 90 ms, FOV 28 cm for younger and 32 cm for older children, matrix 96x96. Acquisition time of DTI for each b-value was 1'04''. Distortions on DT-EPIs were corrected by slice-wise registration of the DTIs onto the first T_2-weighted EPIs using the image registration software FLIRT (www.fmrib.ox.ac.uk/fsl). Using the tensor fitting software DTIFIT to calculate the trace of the diffusion tensor, the mean diffusivity (D) and fractional anisotropy (FA) maps were generated for each b-value. 12 regions of interest (ROI) were defined in D and FA maps to include superior and inferior poles (successively averaged), and the mesorenal region both in the cortex and in the medulla (examples in Figure 1). We calculated mean±SD of D and FA for each ROI and each b value. Differences in D and FA between the affected and the healthy kidney were calculated for each b (Student t-test). Correlations between D, FA and the degree of damage found by scintigraphy were calculated (Spearman test).

Results

Scintigraphy stratified patients into three groups: 1) 6 patients with severe, 2) 4 patients with moderate, 3) 2 patients with mild unilateral functional damage. Healthy kidneys of patients showed D values which decreased with increasing b-value (Fig 2A). as did FA, though less markedly (Fig 2C). D in medulla was lower than in cortex, while FA was 40% higher. In severely affected patients FA values were significantly lower than those in the contralateral kidney for each ROI (Fig 2D) and D was significantly lower only in the cortex of poles (Fig 2B). FA and D in moderately-affected patients were significantly lowered only in the cortex of poles. In the mildly-affected group reduced values of D were found only at higher b-values (600 and 800 s/mm^2) in the cortex of poles. Changes of D and FA for each ROI and b-value correlated with the degree of functionality damage found by scintigraphy ($p<0.05$).

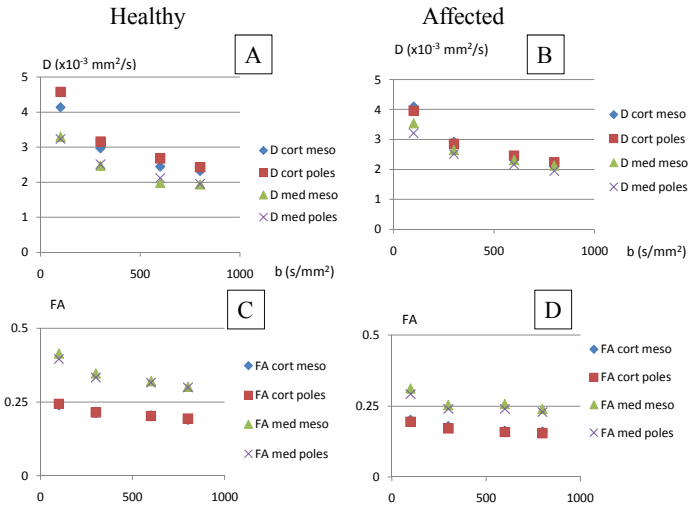
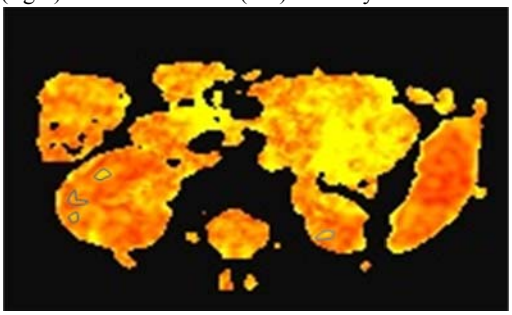


Figure 2. Graph of D and FA values vs b-values in the 12 healthy kidneys (A,C); and in the 6 severely affected kidneys (B, D).

Discussion and Conclusions

Kidney D values strongly depended on the b-value probably because of perfusion contributes at low b-value, as noted elsewhere [1]. FA discriminated values from cortex and medulla better than D [2]; nevertheless the dependence of FA on b-value has not been theoretically explained yet. Unilateral fibrotic damage to the kidney can be detected by both D and FA values: both parameters decrease in the presence of fibrosis with respect to normal values; moreover the degree of abnormality agrees with scintigraphic findings. At higher b-values abnormal D/FA values can be detected even in pyelonephritis patients with mild/small functional impairment.

Figure 1. Example of ROIs within the medulla of healthy (right) and affected (left) kidney in the FA map.



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