Real-time Multi-slice MRI of Renal Filtration in the Mouse

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Introduction

The breathing rate of mice under anesthesia is about 85 per minute, that is about 700 ms per breath. In case of free breathing, the frequency might be even higher and irregular. Thus, to avoid the necessity of respiratory gating, abdominal MRI of the mouse requires a short acquisition time per image. Recently, a new method has been proposed for human real-time MRI combining highly undersampled radial FLASH with a nonlinear inverse reconstruction algorithm[1]. The goal of this study was to evaluate the potential of this technique for mouse studies, where a high spatiotemporal resolution is mandatory and number of elements in radiofrequency (RF) coil arrays is much more limited. In this feasibility study, we performed dynamic contrast-enhanced MRI of renal function with the use of a multi-slice radial FLASH sequence to visualize the excretion of Gd-[DTPA].

Material & Methods

Adult healthy NMRI mice (n = 3) were anesthetized by isoflurane (1.75% in ambient air) via an endotracheal tube. Gd-[DTPA] (0.05 mmol/kg) was injected by intraperitoneal catheter. T1-weighted data sets were obtained using a RF-spoiled radial FLASH sequence (TR/TE = 2.70/1.86 ms, flip angle = 15°, FOV = 58 × 58 mm^2, spatial resolution 0.227 × 0.227 × 1 mm^3) at 9.4 T (Bruker BioSpin, Germany). Signal detection was performed by a 4-channel mouse coil array (Bruker BioSpin, Germany). 125 radial spokes (5 interleaved turns[2]) which together with a nonlinear inverse reconstruction[3] allowed for an acquisition time per image of 70 ms. Because the temporal resolution was much better than physiologically required, the method was extended to a multi-slice experiment (4 sections). Technical reasons resulted in a temporal resolution of 500 ms with an effective repetition time of 20 ms. Dynamic MRI data sets were acquired over a period of 2 hours to cover the whole excretion via the kidneys.

Results

Figure 1 shows a multi-slice acquisition before and after Gd-[DTPA] injection. The signal attenuation due to T2* shortening (highly concentrated Gd-[DTPA]) is clearly visible (Fig. 1, right, arrows). In Figure 2, a selected slice of the data set is shown at different time points, starting with a pre-contrast image. During the excretion process, the accumulation of Gd-[DTPA] in the renal pelvis leads to a dramatic signal drop that further disperses to the cortex and later to the renal medulla. Finally, the enhanced blood vessels become visible. During the ongoing elimination of Gd-[DTPA] the renal mark becomes enhanced followed by a slow signal recovery of the entire kidney.

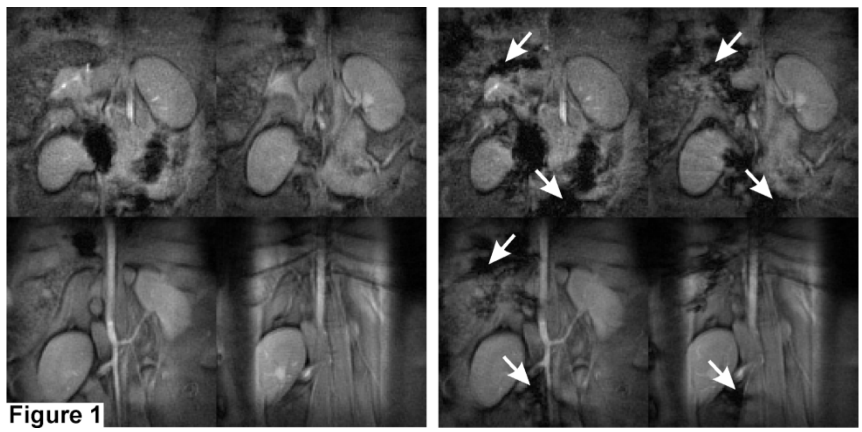

Figure 1

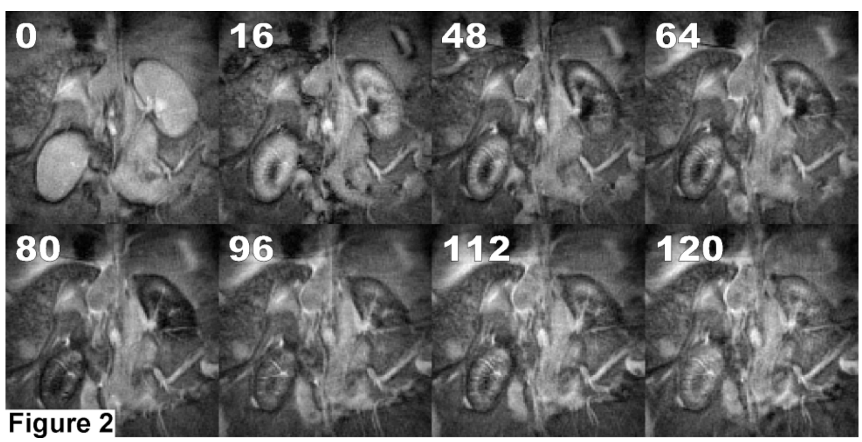

Figure 2

Conclusion

Highly undersampled radial FLASH MRI with nonlinear inverse image reconstruction allows for artifact-free imaging of the mouse abdomen in vivo. Different phases of Gd-[DTPA] excretion by the kidneys could be analyzed with high spatial and temporal resolution. Moreover, the achieved speed facilitated the coverage of both kidneys by multiple sections.

References

[1] Uecker et al. NMR in Biomedicine 2010
[2] Song et al. Magn Reson Med 2000
[3] Uecker et al. Magn Reson Med 2008