# Real-time SPatiotemporal ENcoding Imaging of Renal Kinetics in Perfused Mice

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**Introduction:** One of the real-time MRI aims is to monitor fast dynamic processes by using fast or "ultrafast" (single-scan) schemes. ***SP***atiotemporal ***EN***coding (SPEN) [1] is an ultrafast method capable of delivering single-scan 2D images even in inhomogeneous environments [2], and therefore is a natural candidate for achieving this objective at high fields. The aim of this study was to explore SPEN's ability to deliver real-time dynamics of the contrast material (CM) fast perfusion when injected to mouse kidneys. In the dynamic studies presented below, SPEN-based strategies were compared with similarly structured and timed echo planar imaging (EPI) -based experiments, as well as with multi-scan fast-low-angle shot (FLASH).

**Methods:** Healthy mice were anesthetized and Gd-DTPA was injected into the tail vein with a volume of 100 µL and concentration of 0.01 M. The injection lasted 2sec and all experimental scans thereafter amounted to 20min. These experiments took place at 9.4 T in a Biospec system (Bruker, Germany) using a surface coil for detection and a linear coil for excitation. In figure 1, anatomical images were scanned: 2D SPEN (A), 2D EPI (B) and 2D multi-scan FLASH (C) with FOV of 30×20mm and voxel size of 0.3×0.2×2mm. Further we show 2D SPEN images of both kidneys under the same imaging parameter described before (Fig 2A) and a single kidney (Fig 2B) scan with FOV of 25×15mm and resolution of 0.25×0.15×2mm (Fig.2). Scan durations were 50ms (SPEN), 250ms (EPI) and 1500ms (FLASH), recycling time of 250ms, 4000 repetitions for 20min.

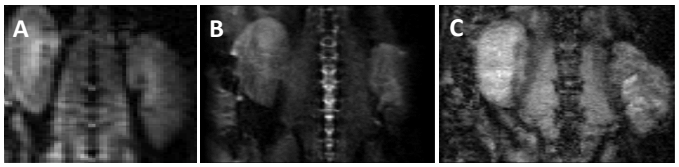


**Fig. 1:** Anatomical images of mouse kidneys before the Gd-DTPA injection: 2D SPEN (A), 2D EPI (B) and multi-scan FLASH (C)

**Results and Discussion:** Figure 1 compares single-slice anatomical images of the targeted areas delivered by SPEN (A), by SE-EPI (B) and by multi-scan FLASH MRI; the kidneys nature even before injecting the CM can be appreciated. The fully refocused SPEN experiment exhibits reduced off resonance effects via spin-echo detection throughout the acquisition process [2]. This feature delivered anatomical images free of artifacts, where EPI suffered from inhomogeneity artifacts surrounding the kidneys ROI. Figure 2A shows a representative single-scan SPEN image of the CM injection (left), as well as a series of kidney images during injection of the Gd-DTPA into the mouse (middle). The SPEN-based method with the shortest scanning time showed a clear spatial advantage since it was the only method among EPI and FLASH that could deliver reasonable images during the Gd-DTPA perfusion into the kidneys under these ultrafast conditions. The kinetic perfusion plots on the right are the mean amplitude of the blue-dotted region, and show the immediate increase in $T_1$-weighted signal due to the arrival of Gd-DTPA into the kidneys and slow flush-out during the plateau until the end of experiment.

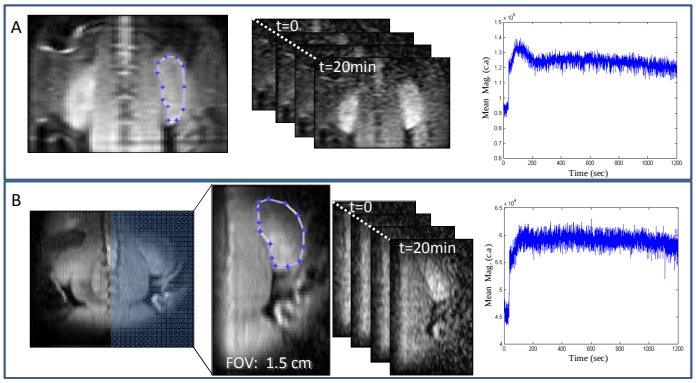


**Fig. 2:** Fast 2D SPEN of both kidneys (A) and single kidney (B) before (left) and during (middle) the Gd-DTPA insertion into the kidneys. The plots describe the mean Gd-DTPA kinetics of the kidney circled by region of interest (ROI).

As expected in applications such as this, when targeting a specific organ, one would prefer to selectively choose a restricted region of interest (ROI) within the sensitive volume of a surface coil without having to re-position. Figure 2B shows how SPEN can easily execute this in the kind of perfusion experiment just described, but focused on one individual kidney –a feature that is not possible using neither EPI nor FLASH. Last, we performed an additional perfusion experiment where we compared the perfusion kinetics between SPEN, SE-EPI and FLASH imaging in different anatomical ROI's of the kidney: Renal-artery, Nephron, cortex and full kidney. A good alignment agreement can be appreciated between the three methods in Figure 3.

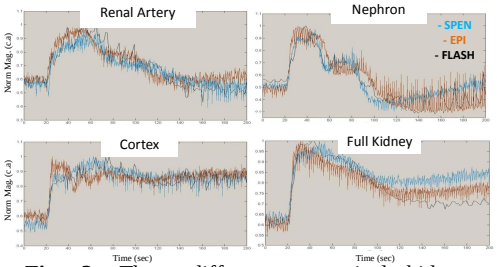


**Fig. 3:** Three different anatomical kidney regions (Renal-artery, Nephron and Cortex) and their time course according to 2D SPEN (blue), EPI (red) and Flash (black).

**Conclusions:** With SPEN artifact-free images, different phases of Gd-DTPA perfusion into the kidneys could be analyzed with high spatial and temporal resolution. This real-time imaging setup as described above can be extended to other biological/physiological settings where such temporal resolution is obligatory.

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**References**: [1] Tal A. and Frydman L., 2010, Prog. NMR Spectrosc., 57, 241-292. [2] Ben-Eliezer, N., Shrot, Y., and Frydman, L., 2010, Magn. Reson. Imag., 28:77-86.