MR RENOGRAPHY: COHERENCE INVESTIGATION BETWEEN THIN SLAB AND WHOLE KIDNEY SCANS

B. Chen[1], Y. Dang[1], X. Yang[2], J. Fang[1,3], X. Wang[1,2], and J. Zhang[1,3]

[1]Academy for Advanced Interdisciplinary Studies, Peking University, BEIJING, BEIJING, China, People's Republic of, [2]Radiology, Peking University First Hospital, BEIJING, BEIJING, China, People's Republic of, [3]College of Engineering, Peking University, BEIJING, BEIJING, China, People's Republic of

Purpose:

Dynamic Contrast-Enhanced MR Renography (MRR) has the potential to provide useful renal functional information to evaluate renal diseases, especially the diffuse renal disease. The MRR is obtained along with dynamic renal perfusion after administration of an intravenous bolus of gadopentetate dimeglumine, and thus has an advantage of noninvasive examination [1]. However, generation of MR renographic curves currently takes at least ten minutes within the clinical setting, and higher temporal resolution is expected to improve the analysis of renal perfusion [2]. The purpose of this study was to determine whether the MRR of the center coronal thin slab scan can effectively represent the renal functional information in patients with diffuse renal disease.

Materials and Methods :

The study protocol was approved by the Hospital Ethics Committee. Five subjects (3 males and 2 females, range 30 - 55 years, mean age 45.2 years) were selected after providing informed consent. In this retrospective study, all the coronal acquisitions were performed on a 3T MR scanner (General Electric Medical Systems, Milwaukee, WI). Three-dimensional MR renography of 10 kidneys with forty-two phases were acquired from T1-weighted MR images which were scanned with LAVA pulse sequence (TR = 4 ms / TE = 0.8 ms, flip angle of 12°, matrix was 256 × 256, section thickness of 3 - 4 mm, FOV of 380 - 400mm). 16 layers of the whole kidney were acquired at each time phase every three seconds after intravenous injection of 3 ml/s (0.025 mmol / kg body weight) of Gd-DTPA (Magnevist, Bayer Schering Pharma AG, Berlin, Germany) and 20 ml saline. The analysis steps were as follows: 1) A modified denoising algorithm with eight adjacencies based on anisotropic diffusion was used to reduce noise. A typical level set framework (C-V model) was successfully applied for automated segmentation with high robustness, and intrarenal compartments were divided into the renal cortex and medulla [3]. 2) The average pixel intensity of regions of interest was computed in all phases, and anatomic regions of the kidney were defined with the greatest corticomedullary differentiation, typically 2 - 6 s after peak enhancement [4]. Then, the cortex and medulla average signal intensity (SI) curves of 12 layers (four of the 16 layers did not cover the kidney and were omitted) were generated (i.e., 2-dimensional MRR of each layer and 3-dimensional MRR of the whole 3-D renal parenchyma). 3) The coefficient of determination was utilized to analyze coherence between the two-dimensional MRR curve of each layer and the three-dimensional MRR curve of the cortex, medulla, and the whole kidney (Fig. 2). 4) In order to determine if the two-dimensional MRR of center thin slab layers represented the MRR curve of the whole kidney, a box plot analysis of three thin slabs (renal anterolateral slab, renal posterolateral slab and renal center slab) was carried out (Fig. 3). Displaying the histogram in conjunction with the boxplot, the center thin slab was determined for the thin slab scan protocol.

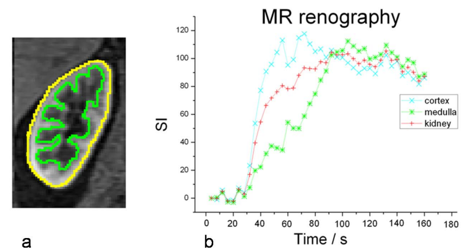

Fig. 1 a) A typical segmentation: renal contour in yellow line, and medulla contour is outlined in green. b) Typical relative signal intensity (SI) curve of a center layer: two peaks in cortex SI curve were noted, after a slight decline, the medulla starts a gradual increase during 1 – 2 min. Cortex enhancement decreased after approximately 2 min.

Results:

Figure 1 illustrates a) the level set based segmentation of renal cortex and medulla, and b) the MR renography of forty- two phases of a typical center thin slab layer. The coefficient of determination between each 2-dimensional and 3-dimensional MRR curve of different renal parenchyma is presented in Figure 2. The first and the last of the 12 layers were omitted from statistical analysis due to inaccuracy of the 2-dimensional data of these layers. Six layers (layers 3 - 8) of the center thin slab exhibited high coherence (0.91±0.11, 0.93±0.12, 0.92±0.13, 0.92±0.10, 0.93±0.12, 0.95±0.05) with the 3-dimensional MRR curve of the whole kidney (Fig. 3 a).

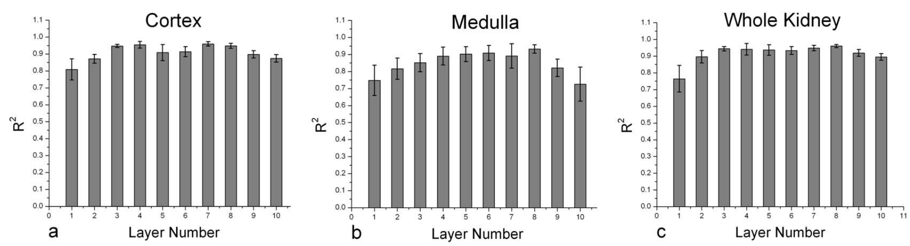

Fig. 2 Histograms of coherence between the 2-dimensional MRR curves of each layer and the 3-dimensional MRR curves of the 3-D renal parenchyma: a) cortex, b) medulla, c) whole kidney.

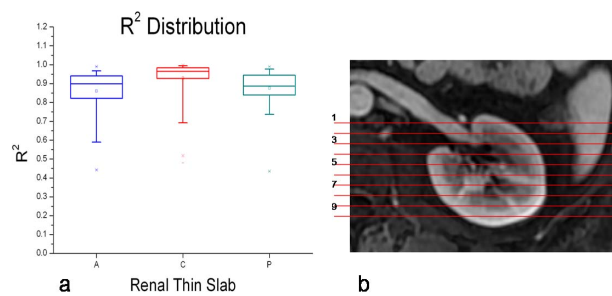

Fig. 3 a) Boxplot for distribution of R^2 of different renal parenchyma: anterolateral slab (blue, layers 1-2), center slab (red, layers 3-8), and posterolateral slab (dark cyan, layers 9-10). b) A sketch illustrating the locations of ten thin slab layers of the whole kidney.

Conclusions:

In this study, we demonstrated that the 2-dimensional MR Renographic curve of any layer of the center thin slab reflects the renal perfusion properties of the whole kidney in diffuse renal disease. Furthermore, a thinner slab scan based on 8 layers instead of 16 layers reduced scan time from three seconds per phase to two seconds. Therefore, the proposed MRR scan strategy based on center thin slab could provide clinically-relevant renal functional information with improved temporal resolution as compared with the conventional 3-D whole kidney DCE-MRI scan protocol in diffuse renal disease.

References:

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