Kidney and Renal Cysts Volume Calculation Based on MR Data: A Reproducibility Study with ADPKD Patients.

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Introduction

Autosomal-dominant polycystic kidney disease (ADPKD) is common hereditary disorder characterized among others by progressive renal cyst growth and end-stage renal disease in the fifth decade of life. In preparation of a larger clinical study we determined the reproducibility of MR volume measurements. Compared to other methods [1] we used a MR protocol which does without the use of contrast agent. For analysis we used a direct volume calculation based on region of interests analysis similar to the one used in [3] instead of indirect stereological methods used previous [2]. Cyst volume calculation is based on a histogram analysis taking advantage of the higher signal of cysts in T2* weighthed MR imaging. The methodology is also interesting for ather applications beyond the context of clinical studies with ADPKD patients and their monitoring during treatment as in [4].

Methods

The MR data were obtained on clinical 1.5 T whole-body systems (Magnetom Espree and Magnetom Sonata, Siemens Erlangen, Germany) using a standard phased array body coil. For localization a standard three plane localizer was acquired. Data acquisition used a half-Fourier single-shot turbo spin-echo (HASTE) sequence followed by two (in-phase and out-of-phase) T1 weighted 2D Flash sequences. The used parameters are for HASTE TE=200ms, TR=652ms and TE=2.38ms res. TE=4.76ms, TR=150ms for Flash sequences. Geometrical parameters were identical for all sequences 256x256 voxel matrix size, FOV=400mm, slice thickness=6mm and coronal slice orientation. Number of slices were varied to make sure full coverage of both kidneys. All data were acquired under breathhold. The overall examination time of the protocol is therefore between 15 to 20 minutes.

7 untreated patients with ADPKD were examined twice within 8 weeks.

DICOM data was transferred to external workstations for further analysis, which was carried out with an in house developed program. Regions of interest (ROI) covering the whole kidney including the cysts were segmented by manual tracing on each slice of FLASH and HASTE images. Possible patient movement between the acquisition of HASTE and FLASH data sets were compensated. ROI drawing was done with an adapted software, which previously proved its value in the analysis of hundreds of DCE-MRI data series with inevitable patient movements.

Using the ROIs the total volume was calculated. ROIs of the HASTE data underwent a histogram analysis to determine a threshold. Counting of pixels above the threshold leads to the volume of the cysts. Thresholds were controlled by visual inspection. Subtraction of this volume of the cysts from the total volume finally gives the noncystic parenchymal volume.

Results

All patients were able to perform examinations with multiple breathholds without problems. Figure 1 shows one slice of a typical HASTE and FLASH data set. Figure 2 displays an example of a histogram analysis leading to a threshold value for cysts volume calculation.

Table 1 lists the percentage changes of the cysts and total renal volume between the two MR examinations. Since patient #7 showed values out of the range of the whole group, a detailed independent radiological reading of the MR-images was performed. This confirmed the occurrence of new cysts and the growth of certain cysts leading to increased total and cystic volume. Within the short interval between examinations used in this study, this is not a typical course of ADPKD patients usually very slowly developing. Since the focus of this study is on reproducibility of such slowly changing patients we skipped the data of this patient before averaging the changes over the whole group. The observed averaged variation in cysts and renal volume was well below 1.5%.

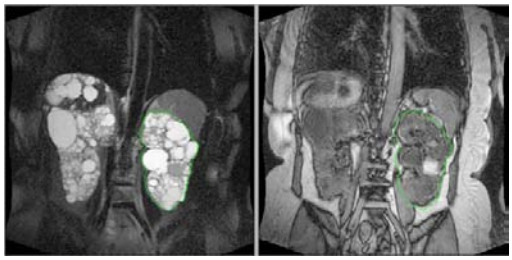

Fig. 1: HASTE / FLASH data set with ROI of one kidney.

Discussion

We could show that the used acquisition protocol and analysis method is robust. The reproducibility of the results between repeated examinations for otherwise within this short periode of time assumed invariable kidneys was very high. This leads to the conclusion that the used method is suitable for a large patient study over a longer period of time. In this study with a double blind scheme the effect of drug res. placebo treatment will be monitored.

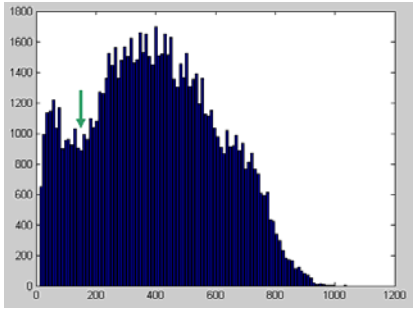

Fig. 2: Histogram analysis of a HASTE data set with chosen threshold.

Pat-ID	cyst vol Σ % change	renal vol Σ % change
#1	0.39%	0.52%
#2	1.18%	2.30%
#3	0.59%	1.31%
#4	0.83%	2.06%
#5	0.97%	0.72%
#6	0.45%	0.06%
#7	8.81%	10.20%
mean	1.89%	2.45%
mean w/o #7	0.74%	1.16%

Tab. 1: Percentage change of cysts and renal volume between the two MR examinations. See remarks to patient #7 in the main text.

References

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