Intra-observer and Inter-observer Variability of Renal Volume Measurements in Polycystic Kidney Disease Utilizing a Semi-automated MR Segmentation Algorithm with HASTE and TrueFISP Sequences

B. A. Cohen[1], I. Barash[2], D. Kim[1], E. Vega[1], M. D. Sanger[1], M. Bloom[1], and H. Chandarana[1]

[1]Radiology, NYU Langone Medical Center, New York, NY, United States, [2]Nephrology, NYU Langone Medical Center

Background

Autosomal Dominant Polycystic Kidney Disease (PKD) is one of the most frequently inherited diseases, affecting approximately 1 in 1000 individuals with a mean age at diagnosis of 43 years[1]. Nearly half of PKD patients undergo dialysis or transplantation by 60 years of age, accounting for 6-12% of dialysis patients in the United States. In PKD, total renal volume and changes in kidney volume have been identified as sensitive markers of disease progression. In a cohort of 232 patients, Grantham and colleagues discovered an average 5.3% annual rise in total kidney volume and decreases in glomerular filtration rate as high as 4.3 mL/min/year among those with the largest, most rapidly growing, kidneys[2]. Serum creatinine levels are less reliable since they often rise late in the course of disease. Therefore, reproducible methods of renal volume quantification may aid in monitoring disease progression and potential responses to novel therapeutics in PKD[3].

Purpose

The aim of this study was to assess the intra-observer and inter-observer reproducibility of a semi-automated MR renal volumetric algorithm in PKD employing fluid sensitive pulse sequences emphasizing cyst conspicuity, specifically HASTE (half-Fourier acquisition single-shot turbo spin-echo) and TrueFISP (true fast imaging with steady-state precession).

Methods

Seventeen patients (2 male, 15 female), 22-58 years old (median: 44), with PKD were studied. Serum creatinine ranged from 0.7 to 2.1 mg/dL (mean: 1.0 mg/dL). Right and left renal volumes (34 kidneys) were segmented from high resolution coronal HASTE (TR/TE$_{eff}$ 1000/94 msec; Matrix 320 x 256; 3 mm slice thickness, no interslice gap, time of acquisition ~ 60 seconds; 4 concatenations) and TrueFISP (TR/TE 3.94/1.97 msec; flip angle 70^{0}; Matrix 256 x 256; 3 mm slice thickness, no interslice gap, time of acquisition ~39 second; 2 concatenations) MR images; TrueFISP data was not available for one patient. Specifically, interpolated three-dimensional surface contours, as demonstrated in Figure 1, were generated based on periodic user-defined two-dimensional outlines. Measurements were performed independently by four readers and were repeated, typically after 7 days. Intra-observer agreement indices were calculated for total kidney volume for each patient as the percent ratio of the absolute difference to mean of repeat measures by the same individual, subtracted from 100%. Inter-observer agreement indices were similarly obtained for each of the 6 paired combinations of readers. Coefficients of variation (CV) were determined for each agreement index.
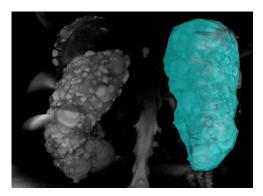

Figure 1. Segmentation performance. This volume rendering of the kidneys, generated from HASTE images, demonstrates innumerable cysts, the hallmark of PKD. The blue overlay on the left kidney depicts the output of the semi-automated volumetric algorithm.

Results

For HASTE (see Table 1), median intra-observer agreement was greater than 98% for each reader with CV less than 2.7% (mean: 1.8%). Median inter-observer agreement was greater than 93% (mean: 95.4%) for each paired combination of readers with CV less than 8.3% (mean: 6.8%). TrueFISP (see Table 1) performed similarly with median intra-observer agreement greater than 97% for each reader with CV less than 3.2% (mean: 2.2%). Median inter-observer agreement was greater than 93% (mean: 94.6%) for each paired combination of readers with CV less than 10.5% (mean: 6.4%). Across all readers, median agreement between HASTE and TrueFISP was 96%. Mean patient processing time was 43 and 28 minutes for HASTE and TrueFISP, respectively. Mean total kidney volume was 1420 mL (range: 331 – 3782 mL) for HASTE and 1445 mL (range: 301 – 3714 mL) for TrueFISP.

Conclusions

The semi-automated MR renal volumetric algorithm provided excellent intra-observer and very good inter-observer reproducibility with relatively long processing time. Inter-observer variability may be decreased with additional anatomic training to distinguish renal cysts from adjacent fluid signal structures. Furthermore, automated volumetric algorithms, which are under development, will hopefully decrease inter-observer variability and processing time to support longitudinal analysis.

References

1. Torres VE et al. *Lancet*. 2007 Apr 14;369(9569):1287-301.
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	Intra-observer Variability		Inter-observer Variability	
	Median Agreement	CV	Median Agreement	CV
HASTE	> 98%	< 2.7% (mean: 1.8%)	> 93% (mean: 95.4%)	< 8.3% (mean: 6.8%)
TrueFISP	> 97%	< 3.2% (mean: 2.2%)	> 93% (mean: 94.6%)	< 10.5% (mean: 6.4%)

Table: Intra-observer and Inter-observer Variability of Renal Volume Measurements