Standardized image acquisition and measurement methods yield accurate total kidney volume assessment in polycystic kidneys via CT or MRI

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Introduction

- Total Kidney Volume (TKV) assessment is a valuable tool for predicting renal prognosis and monitoring progression in autosomal dominant polycystic kidney disease (ADPKD)[1]
- Most reports of TKV measurement are based on MRI and time consuming measurement methods that are difficult to obtain outside of research settings or large academic centers[2]
- Bringing TKV measurement into everyday clinical practice requires imaging protocols that are widely available and interpretation methods that are feasible for clinical radiologists

Objectives

- To evaluate the performance of different imaging modalities and standardized TKV measurement methods
- To identify TKV protocols that are accurate, minimize radiation exposure, and are feasible across diverse clinical/practice settings

Methods

- 30 participants >18 years of age with a known diagnosis of ADPKD participated; diagnosis of ADPKD was confirmed via established diagnostic criteria
- Participants underwent 3 scans; an MRI, a low-dose CT (LD) scan and an ultra-low dose CT scan (ULD). The ULD was also reconstructed via model based iterative reconstruction (MBIR) yielding a 4th image set (Figure 2)
- The images from the 4 modalities were analyzed with three standardized TKV measurement equations (the 'Traditional Ellipsoid,' the 'Mayo Ellipsoid' and the 'Mid-slice Method') and compared to the gold standard of MRI manual planimetry (Figure 1)
- Accuracy, variation and reproducibility of the different imaging modalities and measurement techniques was assessed

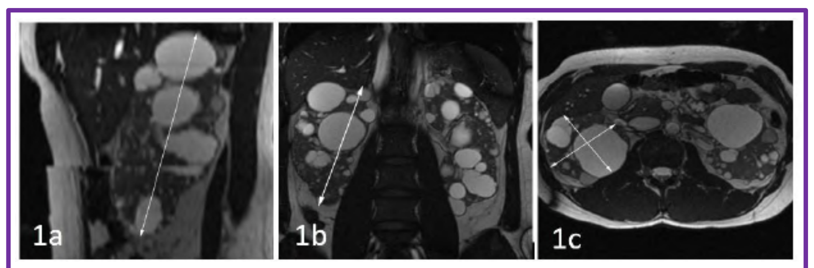

FIGURE 1: Examples of component measurements performed for the ellipsoid and mid-slice method volume calculations

Results

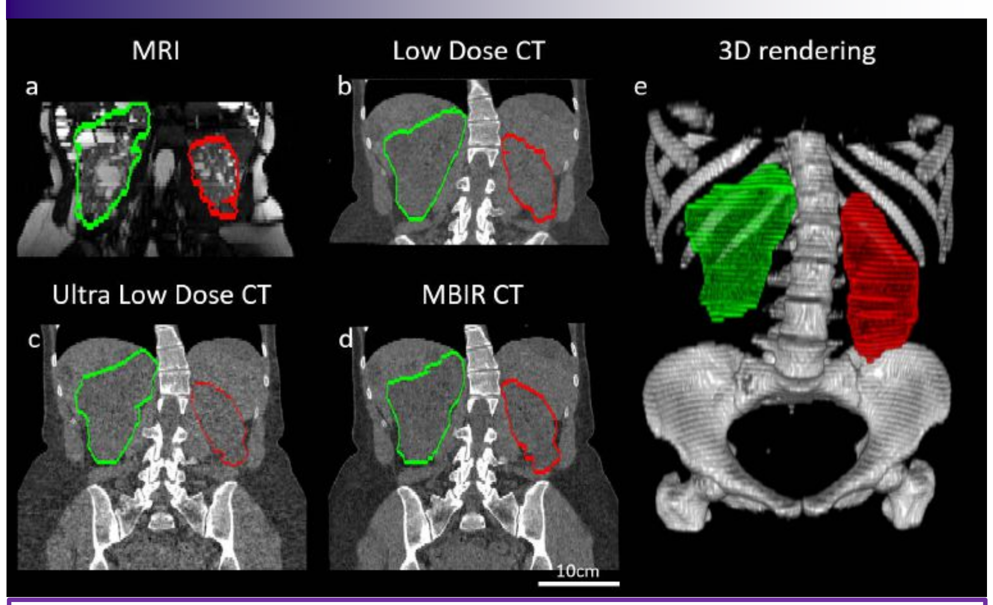

FIGURE 2: Examples of imaging modality types. A-D red and green outlines depict the software-assisted planimetry tracings, image E depicts 3D volume rendering

		Scan Type			
		MRI	LD	ULD	MBIR
Volume equation	'Traditional' ellipsoid	0.994	0.990	0.982	0.992
	'Mayo' ellipsoid	0.994	0.994	0.982	0.994
	Mid-slice method	0.986	0.980	0.951	0.980

TABLE 1: Correlation between the gold standard of MRI manual planimetry and combinations of imaging methods and measurement equations (values shown are r^2 values)

		Scan Type			
		MRI	LD	ULD	MBIR
Volume equation	'Traditional' ellipsoid	4.9 ± 10.4	1.8 ± 10.2	8.3 ± 13.5	4.1 ± 8.8
	'Mayo' ellipsoid	10.5 ± 9.9	8.7 ± 9.4	15.7 ± 14.0	11.4 ± 8.9
	Mid-slice method	2.6 ± 9.8	-1.1 ± 9.9	4.7 ± 17.0	4.0 ± 15.0

TABLE 2: Variation between the gold standard of MRI manual planimetry and combinations of imaging methods and measurement equations (values shown are mean ± SD of percent difference in kidney volumes)

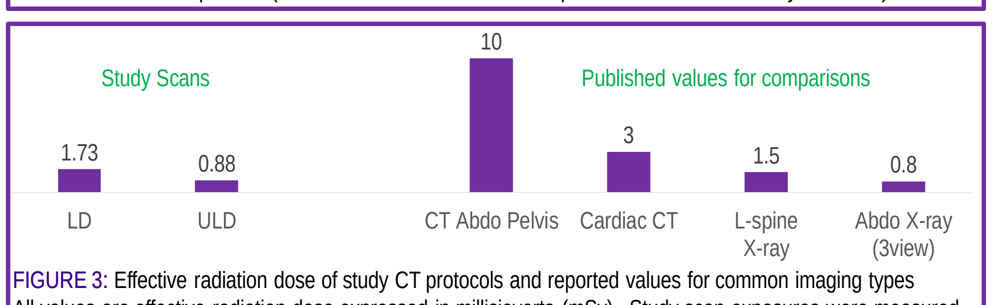

FIGURE 3: Effective radiation dose of study CT protocols and reported values for common imaging types
All values are effective radiation dose expressed in millisieverts (mSv). Study scan exposures were measured for each patient. Published radiation exposures[3] for common scan types are shown for comparison

Results

- All imaging modalities (LD, ULD and MBIR) had excellent correlation with the gold standard MRI (Table 2)
- All measurement equations ('Traditional ellipsoid', 'Mayo ellipsoid' and the 'mid-slice method') had excellent correlation with the gold standard MRI planimetry
- Variation was within ranges reported in previous analyses of TKV, although unconstructed ULD and the mid-slice method showed higher variability (Table 3)
- Intraclass Correlation Coefficients were >0.98 for all methods, demonstrating high reproducibility
- The standardized measurement methods had interpretation times of 5 minutes compared to 45 minutes for the gold standard planimetry method
- LD CT had a mean effective radiation dose of 1.73 mSv while ULD had a dose of 0.88 mSv, a value approaching average exposure for an abdominal x-ray series (Figure 3)

Conclusions

- Detailed measurement instructions can facilitate accurate and reproducible TKV measurements using readily available imaging modalities, with time saving interpretation methods that greatly reduce the burden on interpreting radiologists
- The ULD CT protocol used in this study is associated with a radiation dose similar to an abdominal X-ray series; this may eliminate concerns around the use of CT for routine TKV measurement
- The performance of this variety of standardized TKV measurement methods which may facilitate implementation of TKV assessment in everyday clinical use across diverse practice settings

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References

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