ORIGINAL ARTICLE

CORRELATION OF RENAL LENGTH AND CORTICAL THICKNESS MEASURED ON ULTRASOUND WITH THE DEGREE OF RENAL IMPAIRMENT IN CHRONIC KIDNEY DISEASE

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ABSTRACT

INTRODUCTION: As the burden of chronic kidney disease (CKD) continues to increase, efforts to reduce the cost of monitoring and managing this disease are needed. Aim of this study is to evaluate the usefulness of a generally obtainable measurement at ultrasound in the setting of CKD as a correlate to kidney function. In this study we determined the correlation of ultrasound measured renal length and renal cortical thickness with estimated glomerular filtration rate (eGFR). **METHODOLOGY:** From November 2011 to March 2013, Two hundred (114 men and 86 women, mean age 50 years) clinically diagnosed cases of CKD not on dialysis were studied. The patients were from a single institution. Estimated GFR was determined using Cockcroft and Gault equation. Renal length and cortical thickness were assessed ultrasonographically. The relationships between the renal length and cortical thickness with eGFR respectively were assessed using Spearman's correlation coefficient. **RESULTS:** A statistically significant, positive and strong relationship was observed between eGFR and mean cortical thickness using the CG equations (Pearson's r value=0.596, sig p value). There also was a statistically significant and positive, but weak relationship between CG eGFR and mean renal length (Pearson's r value=0.216, significant p value). **CONCLUSION:** Cortical thickness measured on ultrasound appears to be more closely related to eGFR than renal length. Reporting cortical thickness in patients with CKD who are not on dialysis should be considered.

Key words: Chronic kidney disease, renal function, ultrasound, renal length, renal cortical thickness

Introduction

The burden of chronic renal failure (CRF) has increased exponentially and is consuming the resources of both developed and developing economies, and efforts to reduce the cost of managing this dreadful disease are always welcomed.[1]

Ultrasound was found to be a rapid, effective, radiation-free, portable and safe imaging modality.[2] Because abnormalities of kidney size are present in many renal diseases, it is valuable to have a set of standard sonographic measurements to use when these patients are examined.[3] In diseases involving the kidneys, renal length and cortical thickness are measured usually both at the time of diagnosis and during follow-up.[4,5] These measurements can be made using sonography.[6,7]

Traditional teaching is that renal length correlates with renal function in chronic kidney disease (CKD), and therefore bipolar renal lengths are almost always reported at renal ultrasound.[8] It is also taught that eGFR is better than raised serum creatinine alone, in assessing severity of kidney disease.[9]

Later studies have shown that renal volume calculated

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at ultrasound is a more exact measurement of a functioning kidney than renal length. Progressive renal artery stenosis has been shown to be associated with progressive reduction of renal length.[10,11] A study evaluating patients with suspected unilateral renal artery stenosis showed renal volume was a better predictor of single-kidney GFR than renal length. They also showed the addition of renal area and parenchymal thickness measured at ultrasound to length was a better predictor of both single-kidney GFR and renal volume than length measured at ultrasound alone. A more recent study showed that kidney length and volume significantly correlated with estimated glomerular filtration rate (eGFR) in the elderly, but kidney length has a low specificity in predicting renal impairment. However, measuring the true kidney volume at ultrasound is difficult. Estimates of volume can be made on the basis of the ellipsoid formula, but this method has an inherent defect because the kidney is not actually ellipsoid.[12] In addition, the ellipsoid volume would include the central sinus fat that does not contain functioning renal tissue and does vary from patient to patient. These factors likely contributed to the findings in a recent study that showed a positive, but weak association between sonographically determined kidney volume and various indices of glomerular filtration rate (GFR). The study showed a positive correlation between KV and Cockcroft and Gault estimated GFR($r = 0.471$, $p= 0.003$). The average kidney length was found to significantly correlate with estimated CrCl by the CG equation ($r=0.371$, $p=0.024$).[1]

In patients with CKD, the renal cortical echogenicity increases at ultrasound. In addition, the renal cortex often becomes thinned. A recent study shows that cortical thickness measured on ultrasound appears to be more closely related to eGFR than renal length. There was a statistically significant relationship between eGFR and corticalThickness using CG ($p < 0.0001$). Also there was a statistically Significant relationship between CG and length ($p = 0.003$). Reporting cortical thickness in patients with CKD who are not on dialysis should be considered.[12]

As the burden of CKD continues to increase, efforts to reduce the cost of monitoring and managing this disease are needed. Our study will attempt to evaluate the usefulness of a generally obtainable measurement at ultrasound in the setting of CKD as a correlate to kidney function (eGFR).

The aim of the stud was to determine the correlation between ultrasound measured renal length and renal cortical thickness with estimated glomerular filtration rate (eGFR).

Materials and Methods

This was descriptive cross sectional study conducted at Armed Forces Institute of Radiological Imaging (AFIRI), Rawalpindi from November 2011 to March 2013.Sample size was calculated using PASS software version-11 using correlation coefficient (r) 0.371 of ultrasound measured renal length with eGFR[12] as follows:-

Numeric Results when Ha: R0<>R1

Power	N	Alpha	Beta	R0	R1
0.90304	72	0.05000	0.09696	0.00000	0.37100

A sample size of 72 achieves 90% power to detect a difference of - 0.37100 between the null hypothesis correlation of 0.00000 and the alternative hypothesis correlation of 0.37100 using a two-sided hypothesis test with a significance level of 0.05000. However a sample size of 200 was achieved for the study.

Operational Definitions

Renal Length: The greatest pole to pole distance of kidney in sagittal plane on ultrasound, measured in millimeters (mm).Mean renal length calculated from bilateral measurements.

Renal Cortical Thickness: The shortest distance from the base of medullary pyramid to the renal capsule in sagittal plane at the level of mid kidney on ultrasound, measured in millimeters (mm). Mean renal cortical thickness calculated from bilateral measurements.

Estimated Glomerular Filtration Rate (eGFR): Cockcroft and Gault(CG) equation will be used to estimate GFR (measured in ml/min/1.73m^2) from serum creatinine as follows

$$\text{CrCl (CG)} = \frac{(140\text{-age}) \times \text{lean body weight (Kg)} \times (1.22 \text{ male or } 1.04 \text{ female})}{\text{Serum creatinine } \mu \text{ mol/ l}}$$

Clinically diagnosed cases of CKD, on the basis of impaired renal function for more than 3 months, from both males and females, with an age limit of 20-70 years were included in this study. The patients not included in the study were those on dialysis and those having diabetes mellitus, hydronephrosis or adult polycystic kidney disease (In these conditions kidney size usually increase) as per clinical record. Also those with extremes of ages i.e. <20 years and >70 years (have smaller kidney sizes) & with extremes of body mass (as equation for eGFR do not perform well in such cases) were also not included.

Data collection Procedure: Ultrasound measurements were performed by the primary author which was reviewed by a consultant having 5 years of experience. Right, left and mean measurements were taken. The examinations were performed using standard grey-scale B-mode imaging with a 3.5-MHz curvilinear transducer of Aloka SSD 5500 ultrasound machine. The examination began with the subject supine; the preaortic region was examined to exclude the presence of a horseshoe kidney. Renal measurements were obtained with the subject prone. Length and cortical thickness of the kidney were measured bilaterally. Patient's serum creatinine level measured in MH laboratory during previous one month were used to estimate GFR by Cockcroft and Gault equation. All the information and measurements were recorded on a "Data Collection Performa".

Data analysis Data was entered and analyzed using SPSS version-20. Descriptive statistics was calculated for both qualitative and quantitative variables. Qualitative variable include gender and this was presented as frequency/percentage. Quantitative variables age, weight, ultrasound measured renal length, ultrasound measured renal cortical thickness, serum creatinine level and estimated glomerular filtration rate (eGFR) and these were presented as Mean ± SD. Tables and charts were made for qualitative variables. Pearson's r correlation value and Sig (2-tailed) value were calculated for renal length versus eGFR and renal cortical thickness versus eGFR. P-value less than 0.01 was considered significant.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	114	57.0	57.0	57.0
	Female	86	43.0	43.0	100.0
	Total	200	100.0	100.0	

Table 1: Gender based Frequencies

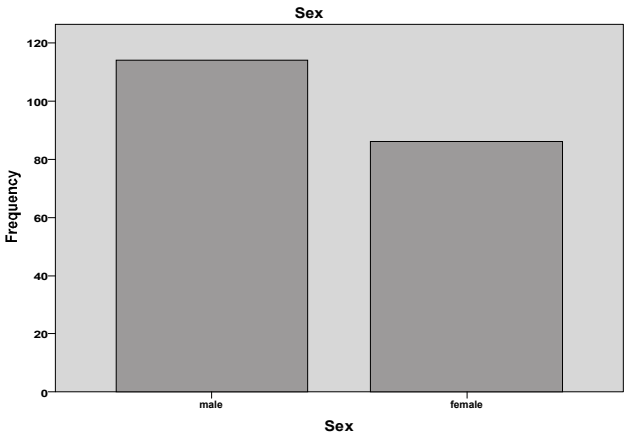

Figure 1: Graph showing gender based distribution of cohort.

Result

The mean cortical thickness was 9.12 mm (range, 2.7–19.4 mm). The mean length was 95.95 mm (range, 48.86 - 124.10 mm). A statistically significant, positive and strong relationship was observed between eGFR and mean cortical thickness using the CG equations (Pearson's r value = 0.596, significant p value). There also was a statistically significant and positive, but weak relationship between CG eGFR and mean renal length (Pearson's r value = 0.216, significant p value). The strongest relationship, as evidenced by the highest Pearson's r value, was for mean cortical thickness and CG eGFR (Pearson's r value =0 .596) (Tab. 2 and 3).

Discussion

Our study showed a statistically significant relationship between cortical thickness measured at ultrasound and renal function in patients with CKD. There was also a significant relationship between CG eGFR

	N	Minimum	Maximum	Mean	Std. Deviation
Age	200	20.00	70.00	50.8500	17.38357
Wt	200	37.00	110.00	63.1500	12.29035
Cr	200	66.00	1493.00	300.8945	309.70758
eGFR	200	3.47	149.85	41.6658	35.62370
RL.R	200	7.90	126.10	95.0741	16.15370
RL.L	200	62.00	132.80	97.4693	14.28915
RL.M	200	48.86	124.10	95.9537	14.21932
RCT.R	200	2.30	18.50	9.1019	3.59463
RCT.L	200	2.70	20.30	9.1758	3.35660
RCT.M	200	2.70	19.40	9.1213	3.34392
Valid N (listwise)	200				

Table 2: Descriptive Statistics

		eGFR	RL.M	RCT.M
eGFR	Pearson Correlation	1	.216**	.596**
	Sig. (2-tailed)		.002	.000
	N	200	200	200
RL.M	Pearson Correlation	.216**	1	.267**
	Sig. (2-tailed)	.002		.000
	N	200	200	200
RCT.M	Pearson Correlation	.596**	.267**	1
	Sig. (2-tailed)	.000	.000	
	N	200	200	200

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3: Correlations

and renal length. Renal length has traditionally been considered a surrogate marker of renal function because renal length decreases with decreasing renal function. Renal lengths are universally reported and are usually the only measurements given at renal ultrasound.[2] However, on the basis of ourstudy; it appears that cortical thickness measured at ultrasound may be related more closely to eGFR than renal length in patients with chronic renal failure. Our study attempted to evaluate the usefulness of a generally obtainable measurement at ultrasound in the setting of CKD as a correlate to kidney function (eGFR). Prior studies also have evaluated imaging measurements as surrogate markers of renal function. A study evaluating 69 patients with suspected unilateral renal artery stenosis showed renal volume was a better predictor of single-kidney GFR than renal length. They also showed the addition of renal area and parenchymal thickness measured at ultrasound to length was a better predictor of both single-kidney GFR and renal volume than length measured at ultrasound alone.[13] Another study showed a correlation between eGFR and renal volumes measured at ultrasound in 116 healthy children.[14] Other authors have described kidney volume as a better predictor of renal function than renal length.[15,16] This was further supported by a study in 2009 by Sanusi et al.[1] showing a weak but positive correlation between kidney volume and various indices of GFR, best with measured creatinine clearance, in 40 patients with CKD. Their results also showed a significant correlation with the measured creatinine clearance and the CG and MDRD equations, further validating these estimates of GFR in CKD.[1] In my study renal cortex measurements were taken perpendicular to the renal capsule from the capsule to the corticomedullary interface. This interface can be difficult to identify in some patients in whom there is poor corticomedullary differentiation. Additional measurements in the transverse plane or an average cortical thickness including the upper and lower poles may prove to be a better representation of functioning parenchymal volume in future studies.

Our study only evaluated patients with CKD and patients on dialysis were necessarily excluded from this study. Examining the relationship between renal function on the basis of serum creatinine and cortical thickness would be inherently flawed in this group because the creatinine used for calculation would be a measure of dialysis efficacy rather than native renal function.

Potential limitation of my study is the use of computational estimates of renal function, rather than measured GFR. Although CG formula has been previously validated.[17,18] A study by Rule et al.[19] in 2004 showed that the MDRD equation systematically underestimated renal function. The underestimation was much more pronounced for healthy volunteers (29% underestimation) than in patients with CKD (6.2% underestimation). However, their study was performed with a version of the MDRD equation before standardization of creatinine estimates between laboratories. The development of the ID–MS-traceable MDRD study equation that was used in their study has allowed the use of standardized creatinine measurements and should minimize measurement differences.[20] A slightly more recent study directly comparing CG and MDRD estimates

of GFR in patients with CKD showed the MDRD equation to be more accurate than the CG equation in patients with moderate to advanced kidney disease and diabetic nephropathy.[21]

Conclusion

Cortical thickness from the capsule to corticomedullary interface at the mid kidney level measured on ultrasound appears to be more closely related to eGFR than renal length. Reporting cortical thickness in patients with CKD who are not on dialysis should be considered.

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