North Bengal Medical College Journal
Vol 2 No 1 January 2016

Original article

Ultrasonographic Measurement of Renal Cortical Thickness in Chronic Kidney Disease Patients

Md. Mofazzal Sharif[1], Md. Towhidur Rahman[2], Md. Shariful Haque[3],
Md. Mostafizur Rahman[4], Mehreen[5]

Revised : September 07, 2015 Accepted : September 22, 2015

Abstract

Introduction: *Cortical thickness measured by ultrasound is said to be related more closely to estimated glomerular filtration rate (eGFR) in patients with chronic kidney disease (CKD). As the burden of CKD continues to rise with increase in treatment cost, measurement of renal cortical thickness by ultrasonography in CKD patients may be done in monitoring and managing CKD more cost-effectively.*

Methods: *This cross sectional study was carried out in the department of Radiology and Imaging Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM) to determine the correlation of ultrasonographically measured renal cortical thickness with estimated glomerular filtration rate in patients with CKD.*

Results: *The age of the patients ranged from 40 to 88 years and the maximum number was found in 7th decade. The mean (±SD) age was 67.9 years with standard deviation ±19.6 years. Male were 23 (58.97%) and female were 16 (41.03%). It was seen that maximum (56.41%) patients' CG eGFR belonged to 30-59 ml/min. The mean (±SD) CG eGFR was 34.3±14.0 ml/min with range from 9.0 to 65.1 ml/min. Majority (56.36%) of the patients had MDRD eGFR within 30-59 ml/min/1.73m^2. The mean (±SD) MDRD eGFR was found 36.3±14.6 ml/min/1.73m^2 with range from 11.0 to 60.9 ml/min/1.73m^2. Mean renal cortical thickness on the right side was 0.61±0.20 cm with range from 0.28 to 1.04 cm and the mean renal cortical thickness on the left side was 0.64±0.21 cm with range from 0.29 to 1.1 cm. Significant positive correlation was found between mean renal cortical thickness and CG eGFR, MDRD eGFR of patients with the clinical diagnosis of chronic kidney disease.*

Conclusion: *Renal cortical thickness measured at ultrasound appeared to relate to the degree of renal impairment in patients with CKD, who were not on dialysis. Routine measurement of renal cortical thickness during reporting should be considered in CKD patients.*

Key words: *Renal cortical thickness, Chronic Kidney Disease, Glomerular Filtration Rate*

North Bengal Med. Coll.J. 2016; 2 (1) : 35-43

1. *Assistant Professor, Radiology and Imaging, North Bengal Medical College, Sirajganj*
2. *Assistant Professor, Radiology and Imaging, BIRDEM*
3. *Assistant Professor, Nephrology, Shaheed M. Mansur Ali Medical College, Sirajganj*
4. *Assistant Professor, Urology, KYAMCH, Sirajganj*
5. *M Phil Resident, Radiology and Imaging, BIRDEM*

Correspondence *Md. Mofazzal Sharif, Email: mofazzal.sharif@gmail.com*

Introduction

Chronic kidney disease (CKD) is a worldwide public health problem. The incidence and prevalence of kidney failure are rising, the outcomes are poor, and the costs of management are high.[1] The incidence, prevalence, mortality, and cost for patients with kidney failure treated by dialysis and transplantation, the end stage of CKD, have increased steadily during the past two decades. Increasing evidences indicates that some of these adverse outcomes can be prevented or delayed by early detection and treatment.[2] Glomerular filtration rate (GFR) is the best measure of overall kidney function in health and disease. The GFR represents the rate at which an ultra filtrate of the plasma is formed by the glomeruli. The normal level of GFR varies according to age, sex, and body size of the patient.[3] Normal GFR in young adults is approximately 120 to 130mL/min per 1.73 m^2 and declines with age. A GFR level less than 60 mL/min per 1.73 m^2 represents loss of half or more of the adult level of normal kidney function. Below this level, the prevalence of complications of chronic kidney disease increases.[4] Determination of endogenous creatinine clearance (measured creatinine clearance) is also used to measure GFR. Creatinine clearance can be computed from a timed urine collection (for example, a 24-hour urine collection) and blood sampling during the collection period. This timed urinary collection is cumbersome and susceptible to error.[3] So in CKD patients because of tubular secretion of creatinine, overestimation of true GFR occurs.[2,4] Chronic kidney disease is defined as either kidney damage or GFR <60 mL/min/1.73m^2 for ≥3 months. Kidney damage is defined as pathologic abnormalities in blood or urine tests or imaging studies. The current Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines of the National Kidney Foundation (NKF) advocate creatinine based equations for estimating GFR to identify patients with potential kidney disease and to classify them into different stages on the basis of these results.[4] The Cockcroft-Gault (CG) and the Modification of Diet in Renal Disease (MDRD) equations are the most widely used formulas to assess renal function and have been proposed by the K/DOQI guidelines to calculate the estimated GFR (eGFR).[1] Ultrasonography is one of the several methods to evaluate renal morphology. Different studies showed that ultrasonography is a rapid and noninvasive diagnostic method for renal diseases and also the first method of choice for screening and follow up of patients and healthy people.[5] Sonography of the kidneys is frequently employed during the evaluation of renal failure. Prior studies also have

evaluated imaging measurements as surrogate markers of renal function. The ultrasound machine is widely available and provides real-time information on the renal dimensions particularly in resource poor settings. In patients with CKD, the renal cortical echogenicity increases at ultrasound. In addition, the renal cortex often becomes thinned. Often this finding occurs with a normal bipolar renal length and an increase in the relative amount of central sinus fat.[6] As the change in renal cortical thickness (RCT) is an important sign of renal disease, ultrasonographic measurement of RCT has been suggested as an index for studying the health status of the kidney.[7,8] This study, was carried out to evaluate ultrasonographic measurement of renal cortical thickness in CKD.

Materials and Methods

The cross sectional study was carried out in the department of Radiology and Imaging, Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM) for a period of one year from July 2011 to June 2012 enrolling 56 patients having the clinical diagnosis of chronic kidney disease (CKD) who were not on dialysis and who had at least three elevated serum creatinine reports within three months. Patients on dialysis were not included in this study because examining the relationship of renal function on the basis of serum creatinine with renal cortical thickness and renal length 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. A total of 17 subjects were excluded due to sonographic findings of hydronephrosis and 39 patients were finally enrolled in this study. A detailed history and physical examination with emphasis on the urinary system was recorded. The lowest creatinine level tested within three months of the ultrasound was used for estimated glomerular filtration rate (eGFR) calculations. The Cockcroft-Gault (CG) and the Modification of Diet in Renal Disease Study (MDRD) equations were used for estimated glomerular filtration rate (eGFR) calculation. All the patients underwent ultrasound examination to measure renal cortical thickness of both kidneys. The renal ultrasound examinations were done by the researcher at first, and then confirmed by a consultant of the Department of Radiology and Imaging to eliminate subjective bias. The Cockcroft-Gault (CG) equation is eGFR (mL/min) = (140 − age) × (Weight in kg) × (0.85 if female)/(72 × S_{cr}), where S_{cr} is serum creatinine in mg/dL. The equation for MDRD study was eGFR (mL/min/1.73 m^2) = 186 × $(S_{cr})^{-1.154}$ × (Age) $^{-0.203}$ × (0.742 if female) × (1.210 if African American), where S_{cr} is serum creatinine in

mg/dL. Creatinine was measured by auto analyzer. All the relevant collected data were compiled on a master chart first. Then the data were organized by using scientific calculator and standard statistical formulae. Further statistical analysis of the results was done by computer software devised as the statistical package for the social sciences (SPSS ver. 20.0).The results were presented in tables, figures, and diagrams. Mean cortical thickness was used in analyses. The relationships between ultrasound measurements and estimated glomerular filtration rate were tested using Pearson's correlation coefficient test. Significance was considered at a 'p' value < 0.05.

Results

The age ranged from 40 to 88 years and the maximum number was found in 7th decade. The mean (±SD) age was 67.9 years with standard deviation ±19.6 years. Male were 23 (58.97%) and female were 16 (41.03%) (Table I).

Table I: Age Distribution of the Study Patients (n=39)

Age (in year)	Number of patients	Percentage
≤50	04	10.25
51-60	09	23.07
61-70	17	43.58
71-80	06	15.38
>80	03	07.72
Total	**39**	**100.0**

It was observed that maximum (56.41%) patients' CG eGFR belonged to 30-59 ml/min. The mean (± SD) CG eGFR was 34.3 ± 14.0 ml/min with range from 9.0 to 65.1 ml/min (Table II).

Table II: Distribution of the Study Patients according to CG eGFR (n = 39)

CG eGFR (ml/min)	Number of patients	Percentage
<15	02	05.12
15-29	12	30.75
30-59	22	56.41
60-89	03	07.72
Total	**39**	**100.00**

Table III shows the MDRD eGFR of the study patients and it was found that maximum (56.36%) patients had MDRD eGFR within 30-59 ml/min/1.73m^2. The mean (±SD) MDRD eGFR was found 36.3±14.6 ml/min/1.73m^2 with range from 11.0 to 60.9 ml/min/1.73m^2.

Table III: Distribution of the study Patients according to MDRD eGFR (n=39)

MDRD eGFR (ml/min/1.73m^2)	Number of patients	Percentage
<15	03	07.72
15-29	11	28.20
30-59	22	56.36
60-89	03	07.72
Total	**39**	**100.00**

Table IV shows the mean renal cortical thickness of the study patients. The mean renal cortical thickness on the right side was 0.61±0.20 cm with range from 0.28 to 1.04 cm and the mean renal cortical thickness on the left side was 0.64±0.21 cm with range from 0.29 to 1.1 cm. The mean renal cortical thickness was 0.62±0.20 cm with range from 0.28 to 0.98 cm.

Table IV: Mean Renal Cortical Thickness of the study Patients (n=39).

	Mean± SD	Range (min-max)
Mean cortical thickness right (cm)	0.61±0.20	(0.28 – 1.04)
Mean cortical thickness left (cm)	0.64±0.21	(0.29 – 1.1)
Mean cortical thickness of both (cm)	0.62±0.20	(0.28 - 0.98)

Correlation between mean renal cortical thickness and CG eGFR (n=39)

Sonographically measured mean renal cortical thickness of 39 patients with the clinical diagnosis of chronic kidney disease was expressed in cm and CG eGFR in mL/min. Significant positive correlation was found between mean renal cortical thickness and CG eGFR of patients with the clinical diagnosis of chronic kidney disease. The values of Pearson's correlation coefficient was 0.826, which is significant ($p<0.001$). Therefore, there was linear strong positive correlation between mean renal cortical thickness and CG eGFR of patients with the clinical diagnosis of chronic kidney disease (Figure 1).

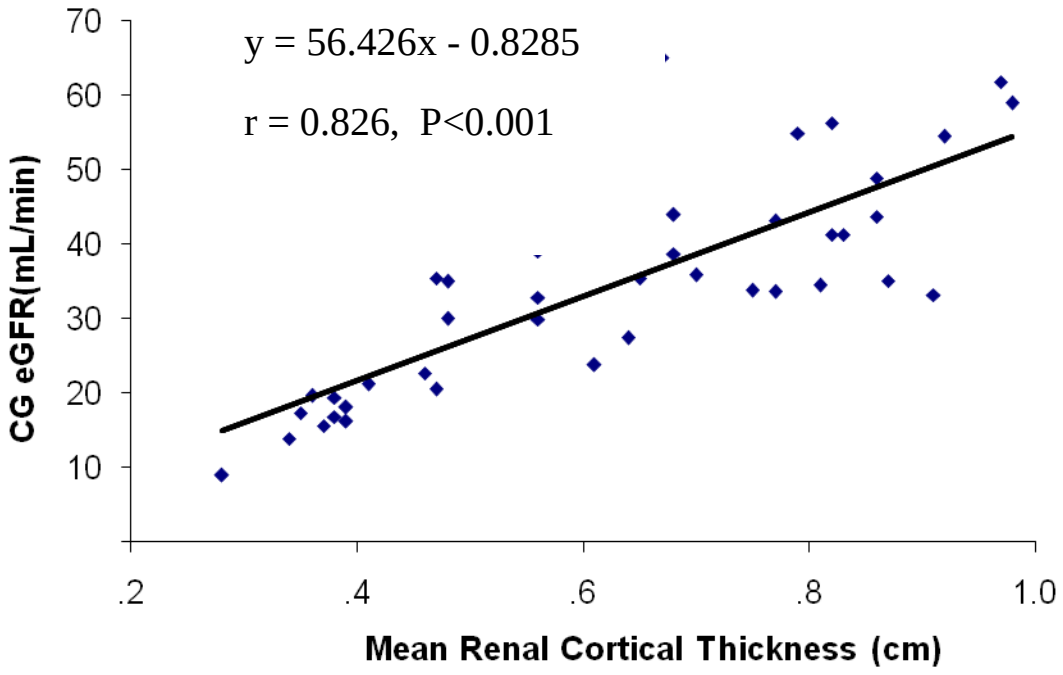

Figure 1: Scatter Diagram Showing the Strong Postive Correlation (r=0.826, p<0.001) between Mean Renal Cortical Thickness (cm) and CG eGFR (mL/min)

Correlation between mean renal cortical thickness and MDRD eGFR (n=39)

Sonographically measured mean renal cortical thickness of 39 patients with the clinical diagnosis of chronic kidney disease was expressed in cm and MDRD eGFR in mL/min/1.73m^2. Significant positive correlation was found between mean renal cortical thickness and MDRD eGFR of patients with the clinical diagnosis of chronic kidney disease. The values of Pearson's correlation coefficient was 0.847, which is significant (p<0.001). Therefore, there was linear strong positive correlation between mean renal cortical thickness and MDRD eGFR of patients with the clinical diagnosis of chronic kidney disease (Figure 2).

Discussion

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. Cortical thickness measured at ultrasound may be related more closely to estimated glomerular filtration rate (eGFR) than renal length in patients with chronic renal failure.[7] As the burden of CKD continues to increase,

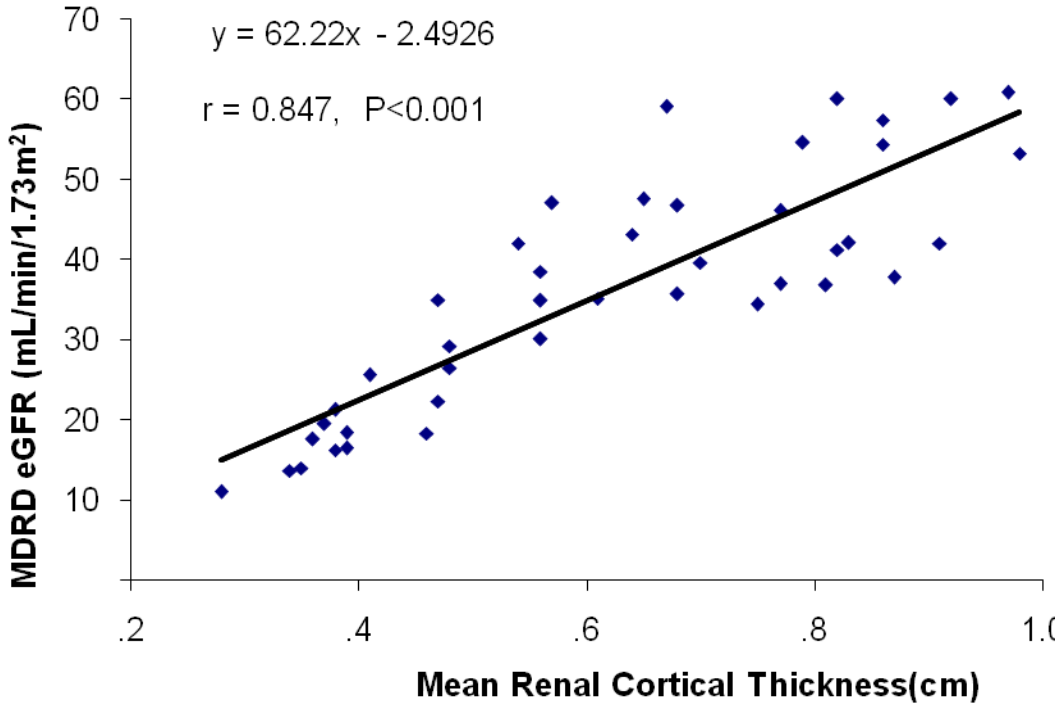

Figure 2: Scatter Diagram Showing the Strong Postive Correlation (r =0.847, p<0.001) between Mean Renal Cortical Thickness (cm) and MDRD eGFR (ml/min/1.73m^2)

efforts to reduce the cost of monitoring and managing this disease are needed. In this current study it was observed that the age ranged from 40 to 88 years and the maximum number was found in 7th decade. The mean (±SD) age was 67.9 ±19.6 years. Male were 23 (58.97%) and female were 16 (41.03%). Researcher[9] found the mean±SD age 56±16 years with range from 34 to 76 years which is comparable with the current study. Levey AS et al.[1] showed that the mean±SD age was 50.6±12.7 years. Studies conducted[9, 10] revealed that the mean age was 45 years with range from 15-82 years and 41±11 years with range from 18-72 years respectively. In this current series it was observed that the mean (±SD) CG eGFR was 34.3±14.0 ml/min with range from 9.0 to 65.1 ml/min and maximum (56.41%) patients had eGFR within 30-59 ml/min and the mean (±SD) MDRD eGFR was found 36.3±14.6 ml/min/1.73m^2 with range from 11.0 to 60.9 ml/min/1.73m^2 and maximum (56.36%) patients had moderately decreased GFR (30-59 ml/min/1.73m^2). Similarly, Beland et al.[7] found the mean eGFR using CG was 34.8 mL/min with range from 10.6–99.4 mL/min and 36 mL/min with range from 8–66 mL/ min using MDRD, which is closely resembled

with the current study. In the current study it was observed that the mean renal cortical thickness of the right kidney was 0.61±0.20 cm with range from 0.28 to 1.04 cm, of the left kidney was 0.64±0.21 cm with range from 0.29 to 1.1 cm and the mean renal cortical thickness of both kidneys were 0.62±0.20 cm with range from 0.28 to 0.98 cm. Previous study[7] showed that the mean cortical thickness was 0.59 cm with range from 0.32–0.11 cm, which was closely matched with the current study. Moghazi S et al.[11] showed the Mean ±SD cortical thickness was 0.83±0.82 cm with range from 0.47-1.25 cm. Adibi A et al.[8] found the mean RCT was 0.91 mm (CI 95%:0.89-0.93mm). The mean RCT was 0.90 cm (CI 95%:0.883-0.921cm) for the right kidney and 0.92 cm (CI 95%:0.90-0.94cm) for the left kidney (P=0.15). In male the mean RCT was 0.93 cm (CI 95%:0.90-0.95 cm) and 0.89cm (CI 95%:0.86-0.91) in female, which was significantly (p=0.02) higher in male subject. Beland MD et al.[7] showed a statistically significant positive relationship between eGFR and mean cortical thickness using both the CG and the MDRD equations (CG, r=0.812, $p < 0.001$; MDRD, r=0.539, $p < 0.001$). There was also a statistically significant relationship between CG eGFR and mean renal length (r=0.548, $p<0.001$) but not MDRD eGFR (r=0.361, $p>0.05$). In another study, Adibi A et al.[8] showed a correlation between GFR and ultrasonographic kidney sizes, especially the kidney thickness. Muto NS et al.[13] mentioned in their study that renal cortical volume had a strong positive relationship with the renal function.

Conclusion

Renal cortical thickness had strong positive correlation with eGFR. Renal cortical thickness measured at ultrasound appeared to relate to the degree of renal impairment in patients with chronic kidney disease, who were not on dialysis. Routine measurement of renal cortical thickness during ultrasonography reporting should be considered in CKD patients.

Contribution of the Authors

First author designed and conducted the study. Others helped in data collection and statistical analysis.

References

1. Levey AS, Schoolwerth AC, Burrows NR, Williams DE, Stith KR, McClellan W. Comprehensive public health strategies for preventing the development, progression, and complications of CKD: Report of an expert panel convened by the Centers for Disease Control and Prevention. Am J Kid Dis. 2009;53(3): 522-535.
2. Remuzzi G, Ruggenenti P, Perico N. Chronic renal diseases: renoprotective benefits of renin-angiotensin system

inhibition. Ann of Inter Med. 2002;136 (8): 604-615.

3. Reiser IW, Porush JG. Evaluation of Renal Function, in Massry & Glassock's Textbook of Nephrology , 4th ed., Lippincott Williams & Wilkins, Philadelphia, Pennsylvania, 2002; p.1793-1801.
4. Yaqoob M. Renal Disease, In Kumar & M Clark (eds). Kumar and Clark Clinical Medicine, 6th ed., Elsevier Saunders: Spain, 2005; p.605-687.
5. Lawson TL, McClennan BL, Shirkhoda A. Adult polycystic kidney disease: ultrasonographic and computed tomographic appearance. J of Clin Ult. 1978;6(5): 297-302.
6. Kabala JE, Robinson PJA, Whittlestone T, Grier D. The urogenital tract: anatomy and investigations, In: Sutton D (eds) Textbook of Radiology and Imaging, 7th ed., Volume 2, Elsevier Churchill Livingstone, India. 2009; p.885-928.
7. Beland MD, Walle NL, Machan JT, Cronan JJ. Renal cortical thickness measured at ultrasound: Is it better than renal length as an indicator of renal function in chronic kidney disease?. AJR. 2010;195: 146-149.
8. Adibi A, Naini AE, Salehi H, Matinpour M. Renal cortical thickness in adults with normal renal function measured by ultrasonography. Iran. JR, 2008;5(3): 163-166.
9. Poggio ED, Wang X, Greene T, Lente FV, Hall PM. Performance of the Modification of Diet in Renal Disease and Cockcroft-Gault equations in the estimation of GFR in health and in chronic kidney disease. J Am Soc Nephrol. 2005;16: 459–466.
10. Rule AD, Larson TS, Bergstralh EJ, Slezak JM, Jacobsen SJ, Cosio FG. Using Serum Creatinine To Estimate Glomerular Filtration Rate: Accuracy in Good Health and in Chronic Kidney Disease. Ann Intern Med. 2004;141(12): 929-937.
11. Moghazi S, Jones E, Schroepple J, Arya K, McClellan W, Hennigar RA, O'neill WC. Correlation of renal histopathology with sonographic findings. Kidney Int. 2005;67: 1515–1520.
12. Emamian SA, Nielsen MB, Pedersen JF, Ytte L. Kidney dimensions at sonography: correlation with age, sex, and habitus in 665 adult volunteers. A J R. 1993;160: 83–86.
13. Muto NS, Kamishima T, Harris AA, Kato F, Onodera Y, Terae S et al. Renal cortical volume measured using automatic contouring software for computed tomography and its relationship with BMI, age and renal function. Eu J R. 2010;78 (1): 151-15