Open Access

Original Article

Correlation of Various Ultrasonographic Renal Parameters With Serum Creatinine Level In Patients of Chronic Kidney Disease

Hafsa Sadiq, Rizwan Bilal, Mobeen Shafique*, Sana Waqar, Qurat-ul-Ain, Sana Ahmad**

Department of Radiology, Armed Forces Institute of Radiology & Imaging / National University of Medical Sciences (NUMS) Rawalpindi Pakistan, *Department of Radiology, Combined Military Hospital Pano Aqil/National University of Medical Sciences (NUMS) Pakistan, **Department of Ophthalmology, Combined Military Hospital Lahore/National University of Medical Sciences (NUMS) Pakistan

ABSTRACT

Objective: To determine the correlation of renal ultrasonographic parameters with serum creatinine levels in patients with chronic kidney disease.

Study Design: Cross-sectional study.

Place and Duration of Study: Armed Forces Institute of Radiology and Imaging, Rawalpindi Pakistan, from Sep 2020 to April 2021.

Methodology: One hundred thirteen patients with chronic kidney disease (Stages 1 to 4) were enrolled in a cross-sectional study. Detailed history and examination were carried out. Serum creatinine levels were carried out, and findings were noted. All patients underwent renal ultrasonography evaluation, kidney parameters were assessed, findings were noted, and statistical analysis was performed.

Results: The mean age of the patients was 42.96±12.71 years, the duration of Chronic kidney disease was 30.38±14.59 months, the length of the kidneys was 7.15±1.84 cm, the volume of the kidneys was 59.4±12.7 ml, the thickness of the renal cortex was 3.78±1.41 cm, thickness of renal parenchyma was 8.33±1.71 mm and serum creatinine levels were 5.36±2.63. Renal ultrasound parameters negatively correlated {for length of kidneys r=-0.187 (p=0.047), for volume r=-0.133 (p=0.161), for cortical thickness r=-0.285 (p=0.002) and parenchymal thickness r=-0.083 (0.382)} with serum creatinine level and only cortical thickness and length of kidneys had significant correlation with it.

Conclusion: Ultrasound assessment is an easy and reliable tool. Measurement of cortical thickness and length of kidneys must be routinely incorporated in the ultrasonographical assessment of patients with Chronic kidney disease.

Keywords: Chronic Kidney Disease, Creatinine, Cortical thickness Kidney, Ultrasonography.

How to Cite This Article: *Sadiq H, Bilal R, Shafique M, Waqar S, Ain QU, Ahmad S. Correlation of Various Ultrasonographic Renal Parameters With Serum Creatinine Level In Patients Of Chronic Kidney Disease. Pak Armed Forces Med J 2024; 74(2): 339-343.*
DOI: https://doi.org/10.51253/pafmj.v74i2.7019

INTRODUCTION

Chronic kidney disease (CKD) is a global health issue with increasing trends in terms of incidence and prevalence.[1] Studies have shown that globally, its prevalence ranges from 8% to 16%, and in Pakistan, 12.6% of the general population suffers from it.[2] It is associated with significant morbidity and high mortality. As the burden of disease is expected to rise, so will the cost of managing it, leading to increased economic burden and utilization of economic resources.[3]

One of the best screening tools for patients with renal insufficiency is ultrasonography. It also helps monitor disease progression.[4] Therefore, almost every individual with CKD undergoes ultrasonographical evaluation at least once during management.[5]

Correspondence: Dr Hafsa Sadiq, Department of Radiology, Armed Forces Institute of Radiology & Imaging Rawalpindi Pakistan
Received: 04 Jul 2021, revision received: 25 Aug 2022; accepted: 31 Aug 2022

Traditionally, it has been seen that the length of kidneys measured by ultrasound is the best parameter for estimating and monitoring renal function in patients with CKD, and it is the most commonly reported parameter.[6] Recently, few studies have questioned its reliability and have proposed that certain other parameters, such as the volume of kidneys, cortical thickness and the thickness of renal parenchyma, are better predictors of the function of kidneys in patients with chronic kidney disease.[7]

Another common marker of renal function is the level of serum creatinine. It is mainly used to estimate glomerular filtration rate, based on which CKD stage is established.8 Many international studies have determined the correlation between serum creatinine levels and renal parameters on ultrasound.[9,10] However, local data is scarce. Therefore, the current study aims to determine the correlation of renal ultrasonographical parameters with serum creatinine levels in patients with chronic kidney disease. This

study will guide the parameter which correlates well with the functioning of kidneys, thus can be used for further assessment and progress of the disease in patients with chronic kidney disease and can help formulate a management plan in such patients, thus decreasing overall morbidity and mortality in individuals with CKD.

METHODOLOGY

The cross-sectional study was conducted at the Armed Forces Institute of Radiology and Imaging, Rawalpindi, Pakistan from September 2020 to April 2021, after obtaining approval from the Ethical Review Committee (IERB approval certificate no 0045). The sample size was calculated, keeping the expected percentage of CKD patients as 8%.[2] The non-probability consecutive sampling technique was used.

Inclusion Criteria: Patients of either gender aged 18 to 65 years, with a diagnosis of Chronic kidney disease as established according to the guidelines of the National Kidney Foundation, were included.

Exclusion Criteria: Patients with single kidney; BMI > 40 kg/m2, i.e. morbid obesity; cirrhosis of the liver; acute renal injury; patients with hydronephrosis; polycystic kidney disease; patients on renal replacement therapy such as hemodialysis, peritoneal dialysis or renal transplant, were excluded.

Ultrasound parameters that were assessed included; the length of the kidneys, i.e. the maximum distance between the two poles in the sagittal plane, the volume of the kidneys, cortical thickness of the kidneys, i.e. shortest distance measured from the pyramid base in the medulla to the capsule of the kidney, i.e measured at the mid-kidney level over a pyramid of renal medulla that was perpendicular to the longitudinal axis of kidneys, thickness of the renal parenchyma i.e. measured from the sinus fat of the echogenic kidneys to the capsule of the kidneys.

One hundred thirteen patients were enrolled in the study after obtaining written informed consent from all patients. Demographical details, clinical history, and physical examination were carried out on all patients, and findings were noted on a predesigned proforma.Baseline investigations such as CBC, serum electrolytes, and serum creatinine levels were carried out, and findings were noted down. All patients then underwent renal ultrasonographical evaluation. Parameters such as renal length, volume of kidneys, cortical thickness, and parenchymal thickness were assessed bilaterally, and a mean of these values was noted on a proforma. All findings were then subjected to statistical analysis.

Data was analyzed using Statistical Package for the Social Sciences (SPSS) version 25.0. Quantitative data was presented as mean and standard deviation. Qualitative data was presented as frequency and percentages. ANOVA test was applied to compare means of renal parameters as assessed on ultrasound and serum creatinine levels. The Pearson correlation test was applied to see the correlation between serum creatinine levels and ultrasound renal parameters; the *p*-value of ≤0.05 was considered significant.

RESULTS

One hundred thirteen patients were included in the study. The results showed that the mean age was 42.96±12.71 years, mean duration of CKD was 30.38±14.59 months, mean length of kidneys was 7.15±1.84 cm, mean volume (in ml) of kidneys was 59.4±12.7, the thickness of renal cortex (in cm) was 3.78±1.41, thickness of renal parenchyma (in mm) was 8.33±1.71 and serum creatinine levels of the patients were 5.36±2.63 (Table-I).

Table-I: Mean Value of Renal Parameters (n=113)

Parameters	Mean±Standard Deviation
Length (in cm) of kidneys	7.15±1.84
Volume (in ml) of kidneys	59.4±12.7
Thickness (in cm) of renal cortex	3.78±1.41
Thickness (in mm) of renal parenchyma	8.33±1.71

There were 67(59.3%) males and 46(40.7%) females, 24(21.2%) had stage I chronic kidney disease, 32(28.3%) had stage II, 30(26.5%) had stage III and 27(24%) had stage IV chronic kidney disease (Table-II). It was found that there was a negative correlation between all parameters and serum creatinine. However, a statistically significant correlation was only present between serum creatinine levels and length of kidneys and cortical thickness of kidneys, as shown in Table-III.

The mean values of ultrasonographic parameters and serum creatinine levels in different age groups and different states according to the duration of chronic kidney disease are mentioned in Table-IV. Table-V shows the post-hoc analysis.

DISCUSSION

The current study assessed the correlation of ultrasonographical parameters of the kidney with serum creatinine levels. The results showed that all

Table-II: Frequency Distribution of Qualitative Variables (n=113)

Variables	n(%)
Stage of CKD	
Stage 1	24 (21.2%)
Stage 2	32 (28.3%)
Stage 3	30 (26.5%)
Stage 4	27 (24%)
Gender	
Male	67(59.3%)
Female	46(40.7%)
Duration of Illness	
Short duration (3 to 12 months)	62(54.9%)
Long duration (13 to 36 months)	30(26.5%)
Extremely long duration (>36 months)	21(18.6%)
Age Groups	
Young age (18 to 30 years)	25(22.1%)
Early middle age (31 to 45 years)	35(31%)
Late middle age (46 to 60 years)	48(42.5%)
Old age (61 to 65 years)	5(4.4%)

A decline in the thickness of renal parenchyma may occur before an increase in creatinine levels is seen in the serum in patients with early kidney dysfunction.[16] Our study found that renal parenchymal thickness was negatively correlated with serum creatinine levels, i.e. an increased serum creatinine level was associated with a decreased parenchyma thickness, thus denoting renal dysfunction. However, this association was not found to be significant. In a previous study this association was weakly significant, i.e. r=0.216, *p* value=0.001.[16] Both Siddapa *et al*.[17] and Jovanovic *et al*.[18] reported a similar correlation.

Previous studies revealed that the length of kidneys was not a good indicator of kidney functions because few patients who underwent renal biopsy based on the findings of the length of kidneys revealed poor prognosis following biopsy.[19,20] In the current study, however, a significant correlation was found between the length of the kidneys as measured on ultrasound and renal function assessed by serum creatinine levels. Mazzotto *et al*. revealed findings similar to those of our study, which showed a significant correlation between the length of kidneys and serum creatinine levels; as the length of kidneys decreased, the creatinine clearance decreased.[21]

Table-III: Correlation of Renal Ultrasonographic Parameters with Serum Creatinine Levels (n=113)

		Length of Kidneys	Volume of Kidneys	Cortical Thickness of Kidneys	Parenchymal Thickness of Kidney
Serum Creatinine Levels	Pearson Correlation	-0.187	-0.133	-0.285	-0.083
	p-value	0.047*	0.161	0.002*	0.382

these factors were negatively correlated with serum creatinine levels, i.e., increased serum creatinine levels; there was a decline in the renal parameters as assessed on ultrasound, thus indicating a deterioration in kidney function. However, a significant correlation with serum creatinine was only found in two parameters, i.e. length of kidneys (r= -0.187, *p*=0.047) and cortical thickness of kidneys (r= -0.285, *p*=0.002).

In individuals who have CKD, the cortex of kidneys often becomes echogenic and thin.[11] This happens because the fat in the central sinus increases. Hence, the assessment of the thickness of the renal cortex on ultrasound has been referred to as a tool for assessing renal health.[12,13] Our study reported similar findings regarding the thickness of the renal cortex being the best indicator of kidney functions in patients with CKD as it significantly correlated with serum creatinine levels. It also significantly correlated with age, gender, CKD duration and CKD stage. In one study, similar findings were reported, i.e. a *p*-value < 0.001.[14] Another study reported a similar relationship between renal cortical thickness and low eGFR in 25 CKD individuals (R=0.66, *p*<0.05).[15]

Another important parameter assessed was kidney volume. Our study revealed that increased serum creatinine levels decreased kidney volume, thus indicating decreased renal function. However, this correlation was not found to be statistically significant.

LIMITATION OF STUDY

Our study had certain limitations. First, administering the International prostate symptoms score questionnaire to persons who still need a high school diploma necessitated interpretation and/or administration by the researchers, perhaps resulting in some bias in the final IPSS score. Second, patients on renal replacement therapy were not assessed; thus, the correlation cannot be applied to such patients.

Table-IV: ANOVA Test Showing Mean Of Ultrasound Parameters and Serum Creatinine Levels According to Age Groups and Duration of Chronic Kidney Disease (n=113)

Groups	n	Length Of Kidneys Mean±SD	Volume Of Kidneys Mean±SD	Cortical Thickness Of Kidneys Mean±SD	Parenchymal Thickness Mean±SD	Serum Creatinine Mean±SD
Age Groups						
Young Age	25	7.9±2.01	62.5±13.6	3.7±1.46	8.24±1.59	5.9±2.97
Early Middle Age	35	6.3±1.51	58.8±13.7	3.96±1.43	8.7±1.61	5.7±2.98
Late Middle Age	48	7.3±1.85	58.4±11.9	3.81±1.4	8.1±1.87	4.7±2
Old Age	5	7.7±1.44	57.4±9.6	2.6±0.69	8±1.58	6.5±3
p-value	-	0.008	0.581	0.240	0.515	0.130
Duration of Chronic Kidney Disease						
Short duration	62	7.2±1.85	58.2±11.5	3.76±1.54	8.45±1.68	5.02±2.49
Long duration	30	6.8±1.93	56.8±13.2	3.96±1.32	8.13±1.66	5.96±2.75
Extremely long duration	21	7.5±1.67	66.5±13.4	3.6±1.15	8.23±1.92	5.5±2.63
p Value	-	0.356	0.014	0.659	0.685	0.273

Table-V: Inter-Group Comparison Table (Post-Hoc Analysis) (n=113)

Groups	Length of Kidneys (in cm) *p* value	Volume of kidneys (in ml) *p* value	Cortical thickness of the kidneys (in cm) *p* value	Parenchymal thickness of the kidneys (in mm) *p* value	Serum creatinine (in mg/dl) *p* value
Young age (18-30 years) vs early middle age (31-45 years)	0.007	0.678	0.755	0.755	0.982
Young age (18-30 years) vs late middle age (46-60 years)	0.553	0.568	0.996	0.996	0.226
Young age (18-30 years) vs old age (61-65 years)	0.998	0.846	0.992	0.992	0.971
Early middle age (31-45 years) vs late middle age (46-60 years)	0.076	0.999	0.494	0.494	0.333
early middle age (31-45 years) vs old age (61-65 years)	0.371	0.996	0.838	0.838	0.913
Late middle age (46-60 years) vs old age (61-65 years)	0.960	0.998	0.998	0.998	0.460
Short duration (3 to 12 months) vs long duration (13 to 36 months)	0.578	0.868	0.685	0.685	0.250
Short duration (3 to 12 months) vs extremely long duration (> 37 months)	0.758	0.024	0.876	0.876	0.753
Long duration (13 to 36 months) vs extremely long duration (> 37 months)	0.338	0.019	0.975	0.975	0.814

CONCLUSION

The current study concludes that ultrasonographic assessment of the kidney is an easy, reliable and non-invasive method. Renal ultrasound parameters show a correlation with serum creatinine levels. However, only renal cortical thickness and length of kidneys, as measured by ultrasound, were significant indicators of kidney function. They can be used in the future for early assessment of renal dysfunction by making their measurement part of the routine ultrasonographical assessment of kidneys.

Conflict of Interest: None.

Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

HS & RB: Conception, study design, drafting the manuscript, approval of the final version to be published.

MS & SW: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

QUA & SA: Data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Ahmed S, Bughio S, Hassan M, Lal S, Ali M. Role of ultrasound in the diagnosis of chronic kidney disease and its correlation with serum creatinine level. Cureus 2019; 11(3): e4241. https://doi.org/10.7759/cureus.4241
2. Mansoor A, Ramzan A, Chaudhary AN. Determination of best grey-scale ultrasonography parameter for assessment of renal function in chronic kidney disease. Ann Pak Inst Med Sci 2016; 12(4): 191-194.
3. Lin HY, Lee YL, Lin KD, Chiu YW, Shin SJ, Hwang SJ, et al. Association of renal elasticity and renal function progression in patients with chronic kidney disease evaluated by real-time ultrasound elastography. Sci Rep 2017; 7(1): 1-8. https://doi.org/10.1038/srep43303
4. Devkota K, Gupta MK, Pant AR, Kark P. Correlation of Duplex Ultrasonographic Parameters with Glomerular Filtration Rate in Chronic Kidney Disease. J Nepal Health Res Counc 2019; 17(1): 32-37. https://doi.org/10.33314/jnhrc.1277
5. Braconnier P, Piskunowicz M, Vakilzadeh N, Müller ME, Zürcher E, Burnier M, et al. How reliable is renal ultrasound to measure renal length and volume in patients with chronic kidney disease compared with magnetic resonance imaging?. Acta Radiol 2020; 61(1): 117-127. https://doi.org/10.1177%2F0284185119847680
6. Peng L, Zhong T, Fan Q, Liu Y, Wang X. Correlation analysis of renal ultrasound elastography and clinical and pathological changes in patients with chronic kidney disease. Clin Nephrol 2017; 87(6): 293. https://doi.org/10.5414/CN108866
7. Levin A, Stevens PE, Bilous RW. Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. Kidney Int Supp 2013; 3: 5–14.
8. Hoi S, Takata T, Sugihara T, Ida A, Ogawa M, Mae Y, et al. Predictive value of cortical thickness measured by ultrasonography for renal impairment: a longitudinal study in chronic kidney disease. J Clin Med 2018; 7(12): 527. https://doi.org/10.3390/jcm7120527
9. Korkmaz M, Aras B, Güneyli S, Yılmaz M. Clinical significance of renal cortical thickness in patients with chronic kidney disease. Ultrasonography. 2018 ; 37(1): 50. https://doi.org/10.14366/usg.17012
10. Gao J, Perlman A, Kalache S, Berman N, Seshan S, Salvatore S, et al. Multiparametric quantitative ultrasound imaging in assessment of chronic kidney disease. J Med Ultrasound 2017 ; 36(11): 2245-2256. https://doi.org/10.1002/jum.14209
11. Yaprak M, Çakır Ö, Turan MN, Dayanan R, Akın S, Değirmen E, et al. Role of ultrasonographic chronic kidney disease score in the assessment of chronic kidney disease. Int Urol Nephrol 2017 ; 49(1): 123-131. https://doi.org/10.1007/s11255-016-1443-4
12. Khadka H, Shrestha B, Sharma S, Shrestha A, Regmi S, Ismail A, et al. Correlation of ultrasound parameters with serum creatinine in renal parenchymal disease. J Gandaki Med Coll Nepal 2019; 12(1): 58-64. https://doi.org/10.3126/jgmcn.v12i1.22619
13. 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?. Am J Roentgenol 2010; 195(2), W146-149. https://doi.org/10.2214/AJR.09.4104
14. Uduagbamen PK, AdebolaYusuf AO, Thompson MU, Ajiboye OF, Nwogbe CI, Oludiran TA. Kidney Volume in Kidney Function Assessment: Determinants and Clinical Correlates in Systemic Hypertension and Chronic Kidney Disease in Southwestern, Nigeria. Open J Nephrol 2020 ; 10(4): 298-310. https://doi.org/10.4236/ojneph.2020.104030
15. Drudi FM, Cantisani V, Granata A, Angelini F, Messineo D, De Felice C, et al. Multiparametric ultrasound in the evaluation of kidney disease in elderly. J. Ultrasound. 2020 ; 23(2): 115-126. https://doi.org/10.1007/s40477-019-00390-5
16. Yang WQ, Mou S, Xu Y, Xu L, Li FH, Li HL. Quantitative parameters of contrast-enhanced ultrasonography for assessment of renal pathology: a preliminary study in chronic kidney disease. Clin Hemorheol Microcirc 2018; 68(1): 71-82.https://doi.org/10.3233/CH-170303
17. Siddappa JK, Singla S, Ameen MA, Kumar N. Correlation of Ultrasonographic Parameters with Serum Creatinine in Chronic Kidney Disease. J Clin Imaging Sci 2013; 3(2): 28. https://doi.org/10.4103/2156-7514.114809
18. Jovanovic D, Gasic B, Pavlovic S, Naumovic R. Correlation of kidney size with kidney function and anthropometric parameters in healthy subjects and patients with chronic kidney diseases. Ren. Fail. 2013; 35(6): 896-900. https://doi.org/10.3109/0886022X.2013.794683
19. Bakker J, Olree M, Kaatee R, de Lange EE, Moons KG, Beutler JJ, et al. Renal volume measurements: accuracy and repeatability of US compared with that of MR Imaging. Radiology 1999; 211(3): 623-628. https://doi.org/10.1148/radiology.211.3.r99jn19623
20. Makusidi MA, Chijioke A, Braimoh KT, Aderibigbe A, Olanrewaju TO, Liman HM. Usefulness of renal length and volume by ultrasound in determining severity of chronic kidney disease. Saudi J Kidney Dis Transpl 2014; 25(5): 1117-1121.
21. Mazzotta L, Sarteschi LM, Carlini A, Antonelli A. Comparison of renal ultrasonographic and functional biometry in healthy patients and in patients with chronic renal failure. Arch Ital Urol Androl 2002; 74(4): 206-209.