Original Research Article Journal of National Heart & Lung Society Nepal

Vol-3. No. 2, Jul-Dec 2024 DOI:10.3126/jnhls.v3i2.71312 ISSN: 2091-0657 (Online & Print)

Correlation of Ultrasonographic Findings with Estimated Glomerular Filtration Rate in Chronic Kidney Disease

Amrit Kharel,[1] **Shreejana Shrestha**,[2] **Dan Bahadur Karki**[2]

[1]Department of Radiology and Imaging, National Academy of Medical Sciences, Bir Hospital, Kathmandu, Nepal, [2]Department of Radiology and Imaging, Patan Academy of Health Sciences, Lalitpur, Nepal.

Received: 14th August, 2024 Accepted: 8th November, 2024 Published: 21th December, 2024

ABSTRACT

Background: Chronic Kidney Disease (CKD) is a condition characterized by kidney damage for three or more months or Glomerular Filtration Rate (GFR) less than 60ml/minute/1.73m^2 for three or more months with or without kidney damage. Ultrasonography is the noninvasive imaging modality to determine the renal morphology. The aim of this study was to find the correlation of ultrasonographic parameters with estimated Glomerular Filtration Rate (eGFR) in CKD patients visiting a tertiary hospital.

Methods: This observational cross-sectional study was carried at Patan Hospital in thirty-five CKD diagnosed cases above the age of 18 years. Renal sonographic parameters like renal length, width, parenchymal thickness, and cortical echogenecity grade were obtained during ultrasonography. eGFR was calculated from CKD-EPI formula after obtaining serum creatinine. Ultrasonographic parameters were compared with eGFR using Spearman correlation test and Kruskal Wallis test was used to check difference in median eGFR among different echogenicity grades.

Results: Statistically significant moderate positive correlation was seen between eGFR and parenchymal thickness ($r_s = 0.51$, $p<0.05$) and eGFR and length ($r_s = 0.46$, $p<0.05$) but weak positive correlation was seen between eGFR and width ($r_s = 0.3$, $p<0.05$). A statistically significant relationship was also seen between eGFR and renal cortical echogenecity grade ($p<0.05$).

Conclusion: Renal parenchymal thickness has maximum positive correlation with eGFR than other parameters to measure renal dimensions like renal length and width. Hence, renal parenchymal thickness is a better parameter to measure renal dimension in patients with CKD.

Keywords: *chronic kidney disease; correlation; eGFR; renal cortical echogenecity.*

INTRODUCTION

Chronic Kidney Disease (CKD), with an increasing incidence and prevalence, is being a worldwide public health problem.[1] Chronic Kidney Disease (CKD) is a condition characterized by kidney damage for three or more months or Glomerular Filtration Rate (GFR) less than 60ml/minute/1.73m^2 for three or more months with or without kidney damage.[2] The worldwide prevalence of Chronic Kidney Disease is estimated to be 8-16%.[3] Prevalence of Chronic Kidney Disease is reported to be 17.4% in India[4] and 6% in Nepal.[5] Ultrasonography (USG) is the ideal imaging modality in CKD because it is non-invasive, less costly, easily accessible, can visualize kidneys and provides sufficient anatomical details. The aim of this study was to find out the correlation of renal length, width and parenchymal thickness with eGFR and association between renal cortical echogenecity grade and eGFR in CKD patients visiting the tertiary care hospital (Patan Academy of Health Sciences).

METHOD

The study was an observational cross-sectional study conducted at the Department of Radiology and Imaging, Patan Hospital, Patan Academy of Health Sciences, Lalitpur, Nepal from March 2021 to March 2022. Any diagnosed cases of CKD who were 18 years or above and were willing to give informed consent were included in the study. Patients on kidney replacement therapy (Haemodialysis, peritoneal dialysis and renal transplantation) or with solitary kidney were excluded from the study. Patients were identified to have CKD as per the confirmed diagnosis made by Internal medicine department of Patan Hospital. Ultrasonography was performed by the researcher at USG room of Patan Hospital when referred by the respective department. As the participants were referred by the department within the hospital there was no extra financial

Correspondence: Dr. Amrit Kharel, Department of Radiology and Imaging, National Academy of Medical Sciences, Bir Hospital, Kathmandu, Nepal. Email: amritkharel2@gmail.com, Phone: +977-9841521702.

burden on patients. Ultrasonography of the kidneys was performed and kidney length, kidney width, parenchymal thickness, cortical echogenecity, and corticomedullary differentiation were evaluated. Renal length was measured as the greatest pole to pole distance in the sagittal plane whereas renal width was measured as the maximum transverse axis in the hilar region.[6,7] Renal parenchymal thickness was measured as the distance between the sinus fat and the renal capsule of the kidney and was obtained at the upper, middle and lower pole.[6] The renal cortical echogenicity was compared to spleen. Renal Cortical Echogenecity Grade ranges from Grade 0 to Grade 4 based on its comparison with the echogenecity of spleen and corticomedullary differentiation.[7] Diagnosed cases fulfilling the inclusion and exclusion criteria were explained about the study design and were assured full confidentiality and an informed written consent was taken subsequently. As all the cases were pre-diagnosed as CKD, only a single serum creatinine measurement within a week before or after ultrasonography were taken in the study and the eGFR was calculated as per the recommendation of National Kidney Foundation using CKD-EPI equation (2021).[8] Patients underwent renal sonography in the supine position. Three readings were measured for kidney length, kidney width, and parenchymal thickness at upper, middle and lower pole and averages of the readings were used as final information. Final kidney length was obtained by averaging the length of both the kidneys. Final kidney width was obtained by averaging the width of both kidneys. Final parenchymal thickness was obtained at the upper, middle and lower pole of both the kidneys and average was calculated to obtain kidney parenchymal thickness. Renal Cortical echogenecity grade was done comparing the echogenecity of renal cortex with that of spleen on the basis of grading as per the operational definition. The required minimum sample size was calculated to be 35 using the correlation r_l= 0.46 for kidney length and eGFR in patients of CKD from the study of Lucisano et al.[6]

Data entry was done in Epi-Info 7 and imported to MSExcel for cleaning. The cleaned file was then imported to the EZR software for further analysis. Descriptive and inferential analyses were done where necessary. Spearman's correlation coefficients were calculated as the dependent variable eGFR showed non-normal distribution. Kruskal Wallis test was used to identify the difference in the median eGFR among different echogenecity grades. Approval of the study was obtained from the Institutional Review Committee (IRC) of PAHS (Reference Number: PMR 2103021486). Informed consent was obtained from all participants before collection of information. Generic PAHS format in English and Nepali were used for written consent. The participation in the study was voluntary and the participants were informed about the option to withdraw from the study at any time without giving any reason during the study period. Confidentiality of the participants was guaranteed by not collecting information on name of the patients and protecting the information on password protected laptop of the researcher.

RESULTS

A total of 35 patients diagnosed with CKD were included in the study. Out of which, 23 (65.7%) were males and 12 (34.3%) were female with male to female ratio of 1.9:1. The patient with minimum age was of 19 years and the patient with the maximum age was of 82 years. Maximum number of the patients belonged to 45-54years (25.7%) and least number of patients were observed in 18-24 years (5.7%). Highest number of patients had Grade II (37.1%) renal cortical echogenicity followed by Grade III (31.5%), Grade I (17.1%) and lowest number of patients had Grade IV (14.3%).

The mean age of the patients with CKD was 53.1±16.4 years with the minimum age of 19 years and maximum age of 88 years. The mean kidney length of the patients with CKD was 8.5±0.8 cm with the minimum of 6.5 cm and maximum of 10.15 cm. The mean of kidney width of the patients with CKD was 3.6±0.4 cm with the minimum of 2.8 cm and maximum of 5.0 cm. The median of the kidney width was 3.5 cm with first quartile (Q1) as 3.3 cm and third quartile (Q3) as 3.8 cm. The mean of kidney parenchymal thickness of the patients with CKD was 1.2±0.2 cm with the minimum of 0.9 cm and maximum of 1.8

cm. The mean of eGFR of the patients with CKD was 14.9±9.0 ml/min/1.73m^2 with the minimum of 4.0 ml/min/1.73m^2 and maximum of 43.0 ml/min/1.73m^2. The median eGFR was 11.0 ml/min/1.73m^2 with first quartile (Q1) as 8.5 ml/min/1.73m^2 and third quartile (Q3) as 18.0 ml/min/1.73m^2.

On Spearman's rank correlation test, a significant moderate positive correlation (r_s = 0.4627546, S = 3835.9, p-value = 0.005124) was identified between eGFR and kidney length (Figure 1); a significant weak positive correlation (r_s = 0.3399252, S = 4712.9, p-value = 0.04572) was identified between eGFR and kidney width (Figure 2); and a significant moderate positive correlation (r_s = 0.5188738, S = 3435.2, p-value = 0.001405) was identified between eGFR and kidney parenchymal thickness (Figure 3). On Kruskal Wallis test, difference in median eGFR in any one of the echogenicity grades was identified. On pairwise comparisons using Mann-Whitney U test with p-value adjustment under Bonferroni method, significant difference in median eGFR was identified among Grade I and Grade III (p= 0.03), Grade I and Grade IV (p=0.05), Grade II and Grade III (p=0.03), Grade II and Grade IV (p=0.02), and Grade III and Grade IV (p=0.03) (Table 1, Table 2 and Figure 4).

DISCUSSION

The study was carried out to establish the reliability of ultrasonography for estimation of kidney function status in patient with CKD by comparing the various renal sonographic parameters with eGFR. Thirty-five patients who had been diagnosed with CKD were included in the study. Mean age of the patients in this study was 53.1 years with majority (more than 70%) above the age of 44 years. Study have identified people with more age to have CKD.[9,10] Moreover, prevalence of chronic illness like hypertension and diabetes is high in older age which may lead to increased number

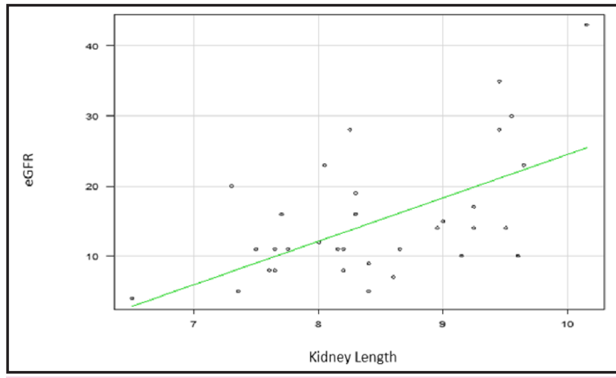

Figure 1. Scatter Diagram Showing Correlation between kidney length and eGFR.

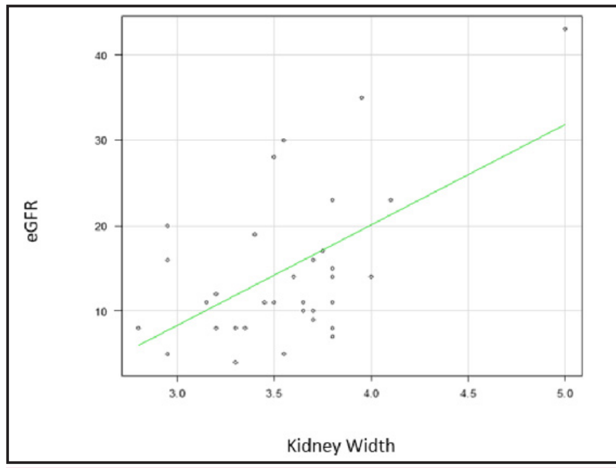

Figure 2. Scatter Diagram showing correlation between kidney width and eGFR.

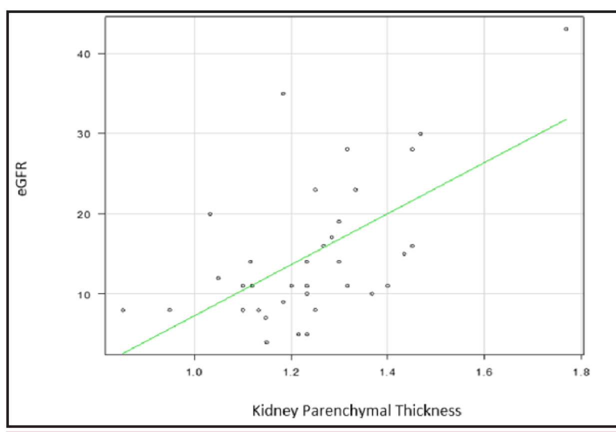

Figure 3. Scatter Diagram showing correlation between kidney parenchymal thickness and eGFR.

Table 1. Relation between Renal cortical echogenicity grade and eGFR.

Variables	Minimum	25% (Q1)	Median	75% (Q3)	Maximum	Kruskal-Wallis chi-squared	Kruskal-Wallis rank sum test p-value
Grade I	11	17.5	29	33.75	43	20.87	<0.001
Grade II	7	14	16	20	28		
Grade III	8	8.5	11	11	14		
Grade IV	4	5	5	8	8		

Table 2. Post hoc test (p-value).

Variables	Grade I	Grade II	Grade III
Grade II	0.68		
Grade III	0.03	0.03	
Grade IV	0.05	0.02	0.03

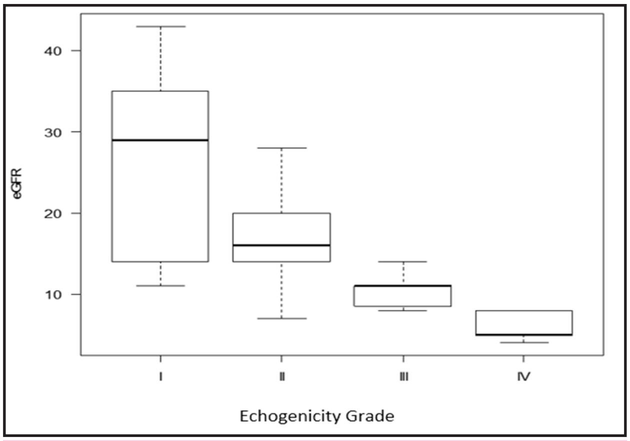

Figure 4. Box plot diagram showing difference in median eGFR of different echogenicity grades.

of CKD patients in older age.[11] Nearly two-third (65.7%) of the patients was male in this study which is similar to the percentage of male patients identified with echogenic kidney in a study by Prashant et al., in Nepal.[12] Study in Italy by Lucisano et al., also shows higher number of males having echogenic kidney.[6] This may be due to faster disease progression among males[13] leading to more health care seeking among males and/or higher tertiary hospital referral. The mean length, median width, and mean parenchymal thickness of the kidney of CKD patients in this study were identified to be 8.5 cm, 3.5 cm, and 1.2 cm respectively. Study in Nepal has shown the normal length and width of the kidney to be 9.56±0.05 cm and breadth was 4.12±0.04 cm respectively.[14] A study in India has identified the normal length, width and parenchymal thickness of the kidney to be 9.65±0.63 cm, 4.5±0.42 cm and 2.04±0.2 cm respectively.[15] Thus, the kidney measurements of CKD patients in our study are lower than the normal measurements as compared to these studies. Kidney measurements are identified to decrease in CKD patients.[16] However, study in Italy by Lucisano et al., has identified the kidney length, width, and parenchymal thickness of the kidney in CKD patients to be around 11 cm, 5 cm and 1.5 cm.[6] Studies have identified different factors like height and race to cause difference in normal kidney measurements as well.[17,18] This study showed higher prevalence of Echogenecity Grade II among CKD patients (37.1%) which shows similarity to the study done by Prashant et al. and Pramod et al., in Nepal[12,19] and Singh et. al, in India.[20] This may be due to easier identification of Grade II echogenic kidney than other grades or may be due to observer bias. Lower number of cases in Grade I may be due to Grade I having minor symptoms in comparison to Grade II and Grade III, thus not seeking health care. Lowest number of cases in Grade IV in our study may be due to patients having done USG in the past or the need for replacement therapy in this group, as the patient under replacement therapy were excluded from this study. This study identified a statistically significant moderate positive correlation ($r_s = 0.46$, $p<0.05$) between eGFR and kidney length. A study to show relation between renal sonographic parameters and eGFR conducted in Italy by Lucisano et. al, has identified a significant moderate positive correlation ($r=0.46, p<0.01$) between kidney length and eGFR[6] which is similar to the findings of this study.[24] A statistically insignificant correlation ($r = 0.206$, $p=0.112$) between kidney length of kidney and eGFR was identified in a study done in Nepal.[12] In this study a statistically significant weak positive correlation ($r_s = 0.3$, $p<0.05$) was observed between eGFR and kidney width of the kidney. A statistically significant weak positive correlation ($r=0.36, p=0.02$) and ($r=0.37$, $p<0.05$) has also been observed between kidney width and eGFR in different study done in Italy and Serbia respectively.[6,21] A statistically significant moderate positive correlation ($r_s = 0.51$, $p<0.05$) between kidney parenchymal thicknesses and eGFR was obtained in our study. In a study in Nepal by Prashant et al., a statistically significant weak positive correlation ($r=0.29$, $p<0.05$) was observed between eGFR and kidney parenchymal thickness.[12] In a study done elsewhere, a significant moderate positive correlation ($r=0.4$, $p<0.001$) was obtained between eGFR and kidney parenchymal thickness.[6] It is observed that among CKD patients (decreased eGFR) the kidney size are reduced owing to sclerosed glomeruli, tubular atrophy and interstitial fibrosis.[16] Thus, this study showed significant correlation between eGFR and different kidney measurements. The difference of this study with some previous studies may be because this study used different formula for eGFR calculation than those studies or may be due to this study using average of multiple readings to minimize kidney measurement bias.

In this study a statistically significant difference in median eGFR was identified among different echogenecity grades. As the echogenecity grade increased there was decrease in renal function i.e. the eGFR reduced gradually from 29 ml/min in Grade I to 16 ml/min in Grade II, 11 ml/min in Grade III and 5 ml/min in Grade IV. A study in India has also identified significant decrease in renal function (increased creatinine) with increase in echogenecity grade.[22] Studies show that there is negative correlation between serum creatinine and eGFR.[23] Studies have shown that cortical echogenecity correlates well with renal histological findings.[16,24] Histological findings in CKD are glomerular sclerosis, tubular atrophy and interstitial fibrosis.[25] Increased cortical echogenecity grade with decreased eGFR in this study may be due to increased severity of the histological findings with worsened renal function in CKD patients. As this study is a single center study with few participants selected through non-random sampling, the findings of the study cannot be generalized. However, the use of multiple readings of kidney measurements and averaging has minimized the observer bias. Also, this study has identified correlation of kidney width and eGFR, which could not be found in studies of Nepal during intensive literature search by the researcher. In addition, the study compared the echogenecity of kidney with the spleen only, thereby minimizing the error that could occur when comparing the echogenecity of kidney with liver having certain conditions (for example fatty liver).

CONCLUSION

This study shows the relationship between the renal ultrasonographic parameters and eGFR in patients with CKD. A statistically significant relationship ($p<0.05$) was obtained between ultrasonographic parameters (Renal dimensions and Renal cortical echogenecity) and eGFR. Thus, ultrasonography can be used as a reliable tool in the assessment of renal function in patients with CKD. Among the different ultrasonographic parameters to measure renal dimensions maximum positive correlation of eGFR was with renal parenchymal thickness and minimum positive correlation with renal width. So, renal parenchymal thickness can be used as the best measurement of renal dimensions to relate with eGFR in CKD patients. Comparison of renal cortical echogenecity with spleen can minimize error that could occur while comparing with liver in certain conditions like fatty liver. Though, this study shows statistically significant relationship between ultrasonographic parameters and eGFR, further validation of the findings by research done in large sample size may be required.

Abbreviation

CKD=Chronic Kidney Disease; CKD-EPI=Chronic Kidney Disease Epidemiology Collaboration; eGFR=estimated Glomerular Filtration Rate; ESRD=End Stage Renal Disease; GFR=Glomerular Filtration Rate; IRC=Institutional Review Committee; K/DOQI=Kidney disease quality initiative; LIC, Low Income countries; MDRD=Modification of diet in renal disease; PAHS=Patan Academy of Health Sciences; r=Karl Pearson Correlation Coefficient; USG=Ultrasonography.

ACKNOWLEDGEMENTS

We would like to acknowledge faculties of Department of Radiology and Imaging and Department of Internal Medicine, Patan Academy of Health Sciences for their valuable inputs during the development of the proposal and collection of data. We would like to thank Dr Gaurav Devkota for his support in review of the analysis and development of the manuscript.

Authors' contributions

A.K., S.S. and D.B.K. conceptualized the study; A.K., S.S. and D.B.K. worked on the methodology; A.K. contributed to document review, data verification, data curation, formal analysis, and data interpretation; A.K. contributed to preparation of first draft of the manuscript; S.S and D.B.K. supervised throughout all the processes. All authors contributed to subsequent revisions and approved the final version submitted for publication.

Conflict of interest: None

Funding: None

REFERENCE

1. Levey AS, Coresh, Josef, Balk Ethan, T. Kausz Annamaria, Levin Adeera, W. Steffes Michael, J. Hogg Ronald J., D. Perrone Ronald, Lau Joseph EGE. Correction: National Kidney Foundation Practice Guidelines for Chronic Kidney Disease. Ann Intern Med. 2003 Oct;139(7):605. [DOI]
2. Bailie GR, Uhlig K, Levey AS. Clinical Practice Guidelines in Nephrology: Evaluation, Classification, and Stratification of Chronic Kidney Disease. Pharmacotherapy. 2005 Apr;25(4):491–502. [DOI]
3. Jha V, Garcia-Garcia G, Iseki K, Li Z, Naicker S, Plattner B, et al. Chronic kidney disease: global dimension and perspectives. Lancet. 2013 Jul;382(9888):260–72. [DOI]
4. Agarwal SK, Srivastava RK. Chronic Kidney Disease in India: Challenges and Solutions. Nephron Clin Pract. 2009 Feb;111(3):c197–203. [DOI]
5. Dhimal M, Karki KB, Sharma SK, Aryal KK, Shrestha N, Poudyal A, et al. Prevalence of Selected Chronic Non-Communicable Diseases in Nepal. J Nepal Health Res Counc. 2019 Nov;17(3):394–401. [DOI]
6. Lucisano G, Comi N, Pelagi E, Cianfrone P, Fuiano L, Fuiano G. Can Renal Sonography Be a Reliable Diagnostic Tool in the Assessment of Chronic Kidney Disease? J Ultrasound Med. 2015 Feb;34(2):299–306.[DOI]
7. 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 Jan;49(1):123–31. [DOI]
8. Miller WG, Kaufman HW, Levey AS, Straseski JA, Wilhelms KW, Yu HYE, et al. National Kidney Foundation Laboratory Engagement Working Group Recommendations for Implementing the CKD-EPI 2021 Race-Free Equations for Estimated Glomerular Filtration Rate: Practical Guidance for Clinical Laboratories. Clin Chem. 2022;68(4):511–20. [DOI]
9. Mallappallil M, Friedman EA, Delano BG, Mcfarlane SI, Salifu MO. Chronic kidney disease in the elderly: Evaluation and management. Clin Pract. 2014;11(5):525–35. [DOI]
10. Weinstein JR, Anderson S. The Aging Kidney: Physiological Changes. Adv Chronic Kidney Dis. 2010 Jul;17(4):302–7.[DOI]
11. Levey AS, Coresh J. Chronic Kidney Disease. Lancet. 2012;379:165–80. [DOI]
12. Gupta PK, Kunwar L, BC B, Gupta A. Correlation of Ultrasonographic Parameters with Serum Creatinine and Estimated Glomerular Filtration Rate in Patients with Echogenic Kidneys. J Nepal Health Res Counc. 2020 Nov;18(3):495–9. [DOI]
13. Ahmed SB, Saad N, Dumanski SM. Gender and CKD. Clin J Am Soc Nephrol. 2021 Jan;16(1):141–3. [DOI]
14. Khanal UP. Estimation of Size of the Kidney in Normal Nepalese Population by Ultrasonography. J Clin Res Radiol. 2018;1(2):1–7. [DOI]
15. Muthusami P, Ramesh A PS. Need For a Nomogram of Renal Sizes in the Indian Population. Indian J Med Res. 2014;139:686–93. PMID: 25027077. [DOI]
16. Moghazi S, Jones E, Schroepple J, Arya K, Mcclellan W, Hennigar RA, et al. Correlation of renal histopathology with sonographic findings. Kidney Int. 2005 Apr;67(4):1515–20. [DOI]
17. CHEN JJ, PUGACH J, PATEL M, LUISIRI A, STEINHARDT GF. The Renal Length Nomogram: Multivariable Approach. J Urol. 2002 Nov;168(5):2149–52. [DOI]
18. Friedenberg MJ, Walz BJ, McAlister WH, Locksmith JP, Gallagher TL. Roentgen Size of Normal Kidneys. Radiology. 1965 Jun;84(6):1022–30. [DOI]

19. Chhetri, PK , Basnet S. ULTRASONOGRAPHY IN PATIENTS WITH CHRONIC KIDNEY DISEASE Pramod. 2021;1(34):110–4. [DOI]
20. Singh A, Gupta K, Chander R, Vira M. Sonographic Grading of Renal Cortical Echogenicity and Raised Serum Creatinine in Patients With Chronic Kidney Disease. J Evol Med Dent Sci. 2016;5(38):2278–4802. [DOI]
21. Jovanović 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 Jul;35(6):896–900. [DOI]
22. Siddappa JK, Singla S, Al Ameen M, Rakshith SC, Kumar N. Correlation of Ultrasonographic Parameters with Serum Creatinine in Chronic Kidney Disease. J Clin Imaging Sci. 2013 Jun;3(1):28. [DOI]
23. Akter N, Nessa A, Sharmin A, Dipa MI, Israt S, Firoz S, et al. Relationship of Serum Creatinine and Estimated Glomerular Filtration Rate in Patients with Chronic Kidney Disease. Mymensingh Med J. 2020 Oct;29(4):779–83. PMID: 33116077. [DOI]
24. Helmberger, T.K. (2009). Parenchymal Disease. In: Gourtsoyiannis, N. (eds) Clinical MRI of the Abdomen. Springer, Berlin, Heidelberg. 2009. p. 225–53. [DOI]
25. López-Marín L, Chávez Y, García XA, Flores WM, García YM, Herrera R, Almaguer M, Orantes CM, Calero D, Bayarre HD, Amaya JC. Histopathology of chronic kidney disease of unknown etiology in Salvadoran agricultural communities. MEDICC Rev. 2014;16(2):49–54. [DOI]

Citation: Kharel A, Shrestha S, Karki DB. Correlation of Ultrasonographic Findings with Estimated-Glomerular Filtration Rate in Chronic Kidney Disease. JNHLS. 2024; 3(2):101-108.