BANGLADESH JOURNAL OF RADIOLOGY AND IMAGING 2025; VOL. 33(2): 83-90

Sonographic Evaluation of Renal Length, Cortical Echogenicity and Renal Thickness of suspected Glomerulonephritis Patients undergoing Renal Biopsy to Predict Irreversible Renal Parenchymal Disease and Comparison with Histopathology

KAZI SHAMA ZINAT[1], M A TAHER[2], SHAMSUNNAHAR SHAMS[3], MD. SAMIUL AMIN PRODHAN[4], TAPOSHI RABEYA[5], FARHANA HABIB[6]

Abstract

Background: *Renal parenchymal disease is a growing global public health concern. Renal biopsy remains the gold standard for evaluating renal parenchymal disease, particularly in cases of nephrotic syndrome, proteinuria, glomerular hematuria. However, ultrasonography offers a non-invasive method to assess renal morphology.* ***Objective:*** *To correlate renal ultrasonographic parameters with histopathology in predicting irreversible renal parenchymal disease.* ***Methods:*** *This cross-sectional study conducted over two years (March 2022 to February 2024) includes 82 adult patients (≥18 years),in the Department of Radiology and Imaging who were referred for image-guided renal biopsy. Renal sonographic findings were compared to biopsy findings, including glomerular sclerosis, interstitial inflammation, fibrosis, and tubular atrophy.* ***Results:*** *Most of the patients were middle aged and with a predominance of comorbid condition like hypertension (67.1%) and diabetes mellitus (54.9%). Grade 2 renal cortical echogenicity was the most common sonographic finding (58.5%). Renal cortical echogenicity demonstrated strong positive correlations with glomerular sclerosis (r = 0.568), interstitial inflammation (r = 0.493), interstitial fibrosis (r = 0.365), and tubular atrophy (r = 0.394), all statistically significant (p < 0.001). Renal length showed significant inverse correlations with these histopathological parameters (r ranging from -0.231 to -0.521; p <0.05). The combination of kidney length <9 cm and cortical echogenicity ≥liver predicted irreversible renal parenchymal disease with a sensitivity of 93.3%, specificity of 94.0%, positive predictive value of 77.8%, negative predictive value of 98.4%, and overall diagnostic accuracy of 93.9%.* ***Conclusion:*** *Ultrasonography is a valuable tool for predicting irreversible renal parenchymal disease by assessing renal length and echogenicity with high diagnostic accuracy in correlation with histopathology, supporting it's use in clinical evaluation of suspected glomerulonephritis.*

Keywords: *Chronic kidney disease, ultrasound, serum creatinine, renal echogenicity, renal insufficiency, chronic, renal parenchyma, ultrasonography.*

Author of correspondence: Dr. Kazi Shama Zinat, MBBS, MD, Junior consultant, Department of Radiology & Imaging, Shaheed Suhrawardy Medical College Hospital, Dhaka, Bangladesh. e-mail: shama.zinat@gmail.com

Introduction:

Renal parenchymal disease is a growing global public health concern. Hypertension and diabetes are leading contributors to chronic kidney damage, while conditions such as chronic glomerulonephritis, systemic lupus erythematosus (SLE),

1) Junior consultant, Department of Radiology & Imaging, Shaheed Suhrawardy Medical College & Hospital, Dhaka, Bangladesh. 2) Professor of BIRDEM Academy & Ibrahim Medical College, Head & Senior Consultant, Department of Radiology & Imaging, BIRDEM General Hospital, Dhaka. 3) Associate Professor, Department of Radiology & Imaging, Shaheed Suhrawardy Medical College & Hospital, Dhaka, Bangladesh. 4) Junior consultant, National Institute of Traumatology and Orthopaedic Rehabilitation, Dhaka. 5) Assistant registrar, National Institute of Burn and Plastic Surgery, Dhaka. 6) Radiologist, Kuwait Bangladesh Friendship Govt. Hospital, Dhaka.

Received: 1 May 2025 **Revised:** 22 May 2025 **Accepted:** 1 June 2025 **Published:** 1 September 2025

and hereditary nephropathies are also significant causes.[1,2] Although most chronic kidney diseases are irreversible, some cases can improve spontaneously or respond to treatment.[3] Timely and accurate assessment is crucial to managing disease progression.

Current diagnostic criteria for chronic renal parenchymal disease include albuminuria, abnormal urinary sediment, electrolyte imbalance, structural abnormalities on imaging or biopsy, and reduced GFR (<60 ml/min/1.73 m²). Among these, biopsy remains the definitive diagnostic tool.[4] But renal biopsy is an invasive procedure with possibilities of complications like renal injury.

Ultrasonography is a safe, non-invasive, and accessible tool for renal assessment. It offers key insights into renal morphology, including kidney size, cortical thickness, and echogenicity, and helps to guide invasive procedures.[5] Elevated cortical echogenicity is often linked with decreased renal function[6] and can be present in both acute and chronic disease.[7] However, the specific correlation between these changes and sonographic parameters needs further exploration.

This study aims to correlate renal ultrasound findings with histopathological results in patients undergoing image-guided renal biopsy.

Method:

This cross-sectional study conducted over two years (March 2022 to February 2024) includes 82 adult patients (≥18 years), admitted to the Department of Nephrology and referred to Department of Radiology and Imaging for image-guided renal biopsy. Patients with hematuria or proteinuria with impaired renal function or systemic disease involvement were eligible, while those with chronic liver disease, bleeding disorders, on anticoagulants, or unwilling to consent were excluded. All sonographic assessments were performed using a 3.5 to 5 MHz curvilinear transducer in supine, prone, and decubitus positions. Renal length was measured as the pole-to-pole distance; cortical and parenchymal thickness were measured at the mid-region, with cortical thickness from the medullary pyramid base to the capsule and parenchymal thickness from sinus fat to the capsule. Cortical echogenicity was graded relative to the liver or spleen (Grade 0–2). Biopsies, preferably from the left kidney, were performed under ultrasound or CT guidance using a Geotek spring-loaded biopsy gun with a 16G core needle. Specimens were fixed in normal saline and 10% formalin for histopathological analysis with grading glomerular sclerosis (0–4), interstitial fibrosis, inflammation, and tubular atrophy (each 0–3) based on severity. All imaging and histology assessments were done independently. A structured questionnaire was used as a research tool.

Statistical Analysis:

Data were analyzed using SPSS version 26. Group comparisons used ANOVA or chi-square tests. Spearman's correlation assessed relationships between sonographic and histopathological parameters.

Results

The study included 82 participants, with the majority aged between 41–50 years (36.6%), followed by 28.0% aged 18–30 years. In terms of gender distribution, males slightly outnumbered females (53.7% vs. 46.3%). Regarding comorbidities, hypertension was the most prevalent condition, affecting 67.1% of patients, followed by diabetes mellitus, present in 54.9% of cases.

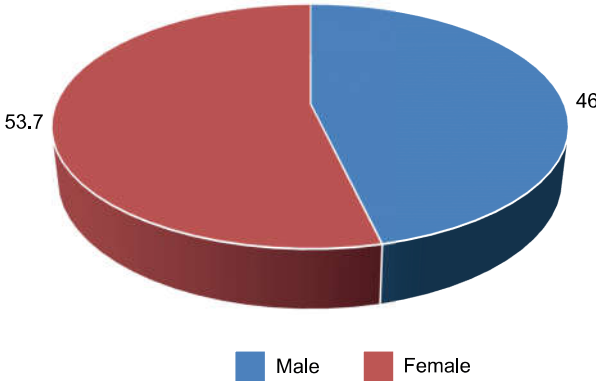


Fig.-1: *Distributions of the study subjects by gender (n=82)*

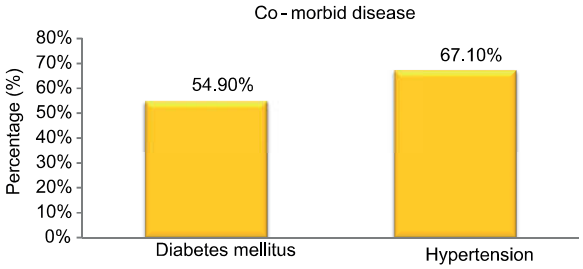


Fig.-2: *Distributions of the study subjects by co-morbid disease (n=82)*

Most patients showed mild to moderate glomerular sclerosis (Grades 1–2 in 63.4%), with severe changes (Grades 3–4) in 18.3%. Interstitial inflammation was present in 74.4% of cases, with 14.6% showing severe involvement. Interstitial fibrosis and tubular atrophy were absent or mild in most patients (70.8% and 80.5%, respectively), while severe changes were less common (6.1% fibrosis, 8.5% atrophy), indicating varying stages of chronic renal damage.

Among histopathological diagnoses (15.9%) patients had minimal change disease followed by 12(14.6%) IgA nephropathy; 16(19.5%) patients had diabetic nephropathy,with 9(11.0%) lupus nephritis and 1(1.2%) membranous nephropathy.

A significant inverse relationship was observed between kidney echogenicity and eGFR ($p = 0.005$), with higher echogenicity grades associated with lower mean eGFR, indicating worsening renal function.

Table 1 shows that renal length is significantly associated with the degree of glomerular sclerosis. Both right and left kidney lengths progressively decrease with increasing sclerosis severity ($p = 0.001$). However, cortical and parenchymal thicknesses did not show a statistically significant correlation with glomerular sclerosis ($p > 0.05$).

Table-I

Association between Ultrasonographic parameters with glomerular sclerosis (n=82)

Ultrasonographic findings(cm)	Glomerular sclerosis					p value
	Grade 0 (n=15) Mean±SD	Grade 1 (n=33) Mean±SD	Grade 2 (n=19) Mean±SD	Grade 3 (n=8) Mean±SD	Grade 4 (n=7) Mean±SD	
Length of RK	9.98±0.72	9.59±0.72	9.19±0.56	8.84±0.26	8.81±0.22	0.001[s]
Length of LK	10.31±0.73	9.84±0.89	9.45±0.54	8.96±0.67	8.91±0.23	0.001[s]
C. thickness (R)	0.92±0.18	0.88±0.19	0.8±0.19	0.69±0.2	0.77±0.28	0.050[ns]
C. thickness (L)	0.98±0.23	0.92±0.23	0.88±0.24	0.79±0.25	0.84±0.33	0.378[ns]
P. thickness (R)	1.68±0.32	1.55±0.3	1.35±0.3	1.15±0.37	1.39±0.35	0.061[ns]
P. thickness (L)	1.71±0.31	1.58±0.28	1.52±0.28	1.34±0.36	1.54±0.41	0.088[ns]

p value reached from ANOVA test
Glomerular sclerosis were graded from 0 to 4 ; (Liborio et al., 2017).[8]
Grade 0: <5% sclerosis
Grade 1: 6 %to 25% glomerular sclerosis
Grade 2: 26% to 50% glomerular sclerosis
Grade 3: 51% to 75% glomerular sclerosis
Grade 4 : > 75% glomerular sclerosis

Table-II

Histopathology at different thresholds for sonographic parameters (n=82)

Sonographic Parameter	N (USG)	Irreversible renal parenchymal disease diagnosed by histopathology		p value
		n	%	
Kidney length less than 9 cm	19	14	73.7	0.001[s]
Kidney length greater than or equal to 9 cm	63	1	1.6	
Echogenicity less than liver	10	0	0.0	0.001[s]
Echogenicity greater than or equal to liver	72	15	20.8	
Kidney length less than 9 cm and echogenicity greater than or equal to Liver	18	14	77.8	0.015[s]
Kidney length greater than or equal to 9 cm and Echogenicity less than liver	9	0	0.0	

p value reached from Chi-square test

Table-III

Comparison between histopathological findings and USG assessment for suspected glomerulonephritis patients (kidney length less than 9 cm and echogenicity greater than or equal to liver) (n=82)

USG	Histopathology		P value
	Positive(n=15)	Negative(n=67)	
Positive (n=18)	14(True positive)	4(False positive)	0.001[s]
Negative (n=64)	1(False negative)	63(True negative)	
Validity test		Values	
Sensitivity		93.3	
Specificity		94.0	
Accuracy		93.9	
Positive predictive value		77.8	
Negative predictive value		98.4	

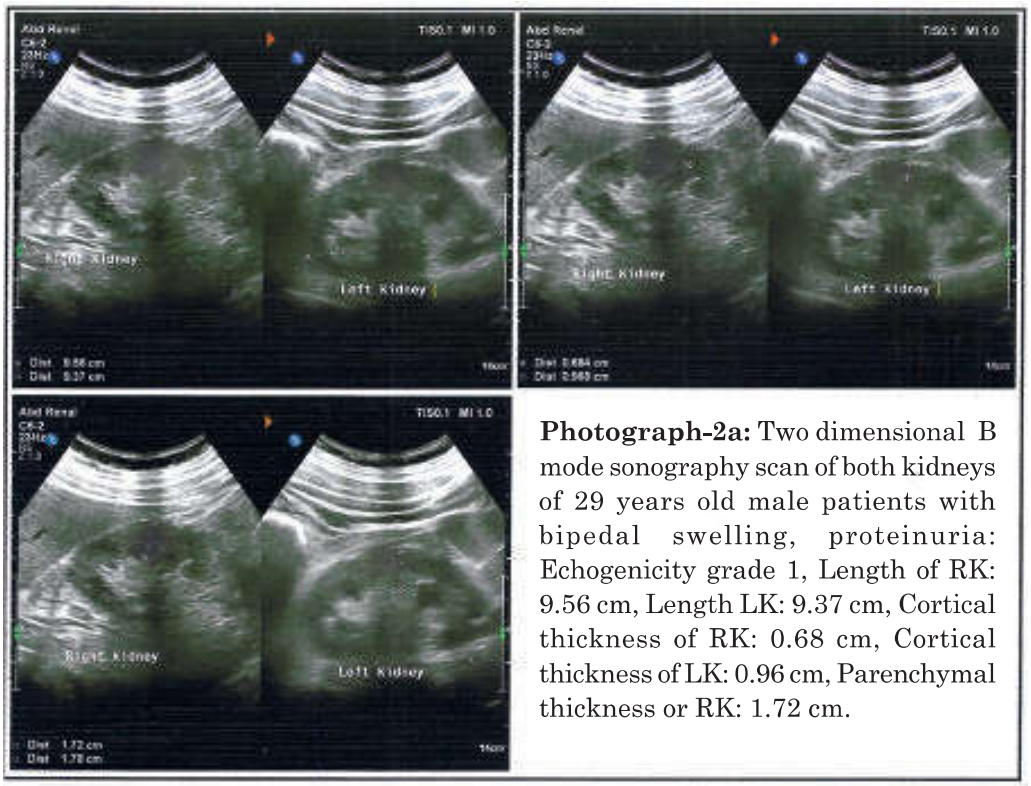
p value reached from chi-square test

Table II shows a strong association between sonographic parameters and histologically confirmed irreversible renal parenchymal disease. A kidney length <9 cm was associated with irreversible damage in 73.7% of cases (p = 0.001), while echogenicity e" liver predicted irreversible disease in 20.8% (p = 0.001). When both markers-short kidney length and increased echogenicity-were present, 77.8% had irreversible pathology (p = 0.015).

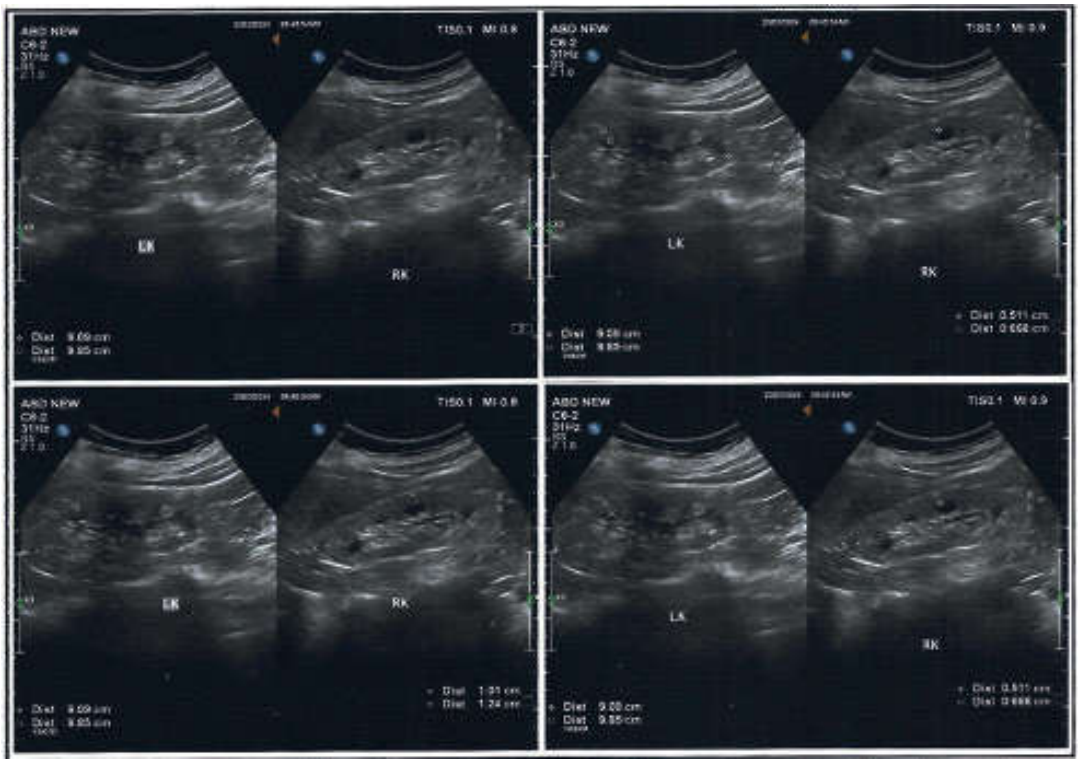
Table III compares ultrasound findings with histopathological results in detecting irreversible renal parenchymal disease. Using the combined criteria of kidney length <9 cm and echogenicity ≥ liver, ultrasound demonstrated high diagnostic performance with a sensitivity of 93.3%, specificity of 94.0%, and overall accuracy of 93.9%. The positive predictive value was 77.8%, while the negative predictive value was 98.4%, indicating that this sonographic approach is highly reliable in ruling out irreversible disease and moderately effective in confirming it. The association was statistically significant (p = 0.001).

Renal echogenicity showed a strong and significant positive correlation with all histopathological parameters: glomerular sclerosis (r = 0.568), interstitial inflammation (r = 0.493), interstitial fibrosis (r = 0.365), and tubular atrophy (r = 0.394), all with p = 0.001. Kidney length (both right and left) demonstrated a significant negative correlation with glomerular sclerosis (r = -0.521 and -0.520), interstitial inflammation (r = -0.231 and -0.252), fibrosis (r = -0.238 and -0.244), and atrophy (r = -0.268 and -0.269), all **p < 0.05**. Cortical and parenchymal thicknesses showed weaker and mostly non-significant associations, highlighting renal echogenicity and length as the most reliable sonographic indicators of chronic renal damage.

Photograph-1a: Two dimensional B mode sonography scan of both kidneys of 41 years old male patients with bipedal swelling, proteinuria: Echogenicity grade 0, Length of RK: 9.20 cm, Length LK: 10.5 cm, Cortical thickness of RK: 0.73 cm, Cortical thickness of LK: 0.78 cm, Parenchymal thickness or RK: 1.74 cm, Parenchymal thickness LK: 1.89 cm.



Photograph-2a: Two dimensional B mode sonography scan of both kidneys of 29 years old male patients with bipedal swelling, proteinuria: Echogenicity grade 1, Length of RK: 9.56 cm, Length LK: 9.37 cm, Cortical thickness of RK: 0.68 cm, Cortical thickness of LK: 0.96 cm, Parenchymal thickness or RK: 1.72 cm.



Photograph-3a: Two dimensional B mode sonography scan of both kidneys of 23 years old male patients with proteinuria: Echogenicity grade 2, Length of RK: 9.85 cm, Length LK: 9.09 cm, Cortical thickness of RK: 0.511 cm, Cortical thickness of LK: 0.67 cm, Parenchymal thickness or RK: 1.24 cm, Parenchymal thickness LK: 1.01 cm

Discussion

This cross-sectional study aimed to assess the diagnostic value of renal ultrasonography in predicting irreversible renal parenchymal disease by correlating sonographic findings with histopathology conducted at BIRDEM General Hospital between March 2022 and February 2024, it included 82 patients referred for image-guided renal biopsy. The goal was to establish clinical thresholds for renal length and cortical echogenicity to support non invasive decision making in suspected glomerulonephritis.

The study population had a mean age of 42.34 ± 14.54 years, with the highest proportion (36.6%) aged 41–50 years. This aligns with previous regional studies, suggesting that renal impairment becomes more prominent after age 40 due to physiological decline in GFR and increased prevalence of comorbid conditions like diabetes and hypertension. Female patients slightly outnumbered males (53.7% vs. 46.3%), consistent with findings from Liborio et al.[8], though other studies, like Kausar et al.[1], reported a male predominance.

Comorbidities were common, with 67.1% having hypertension and 54.9% diabetes mellitus—both key risk factors for CKD. The average eGFR was 62.88 ± 17.51 ml/min/1.73 m², indicating varying stages of renal dysfunction, similar to values reported by Araujo et al.[9]

Sonographically, the mean kidney length was 9.43 cm (right) and 9.67 cm (left), which aligns with regional norms. Cortical thickness averaged 0.84 cm (right) and 0.86 cm (left), with a small inter-kidney difference. These values correspond with earlier findings from Ahmed et al.[10] and Kodikara et al.[11] Diabetic nephropathy was the most frequent histological diagnosis (19.5%), followed by minimal change disease and IgA nephropathy—reflecting the patient population of an endocrine hospital.

Histopathological grading revealed varied degrees of glomerular sclerosis, interstitial inflammation, fibrosis, and tubular atrophy. As per Sethi et al[12] ,these represent chronic, often irreversible, changes.

A key finding of this study was the strong positive correlation between cortical echogenicity and all four histopathological markers ($p<0.001$). This supports the hypothesis that echogenicity increases with interstitial fibrosis and glomerulosclerosis, as shown by Liborio et al.[8] Echogenicity thus serves as a non-invasive proxy for chronic damage.

Renal length showed significant inverse correlations with glomerular sclerosis, inflammation, fibrosis, and atrophy ($p < 0.05$), reinforcing its role as a marker of irreversible change. Moghazi et al.[13] similarly found negative correlations between renal length and chronic pathology, consistent with our findings.

Cortical thickness correlated significantly only with glomerulosclerosis ($p<0.05$), while showing no meaningful association with inflammation, fibrosis, or atrophy. This Additionally, diabetic patients—who formed a substantial portion of this cohort—may have variable cortical measurements, as highlighted by Kodikara et al.[11]

Parenchymal thickness, like cortical thickness, showed weak or non-significant correlations, in line with results from Jalili et al.[14] Measurement errors, poor corticomedullary demarcation in chronic disease, and operator variability likely contribute to this limitation, as noted by Bracconnier et al.[15] To define irreversible renal parenchymal disease, histological thresholds included >50% glomerular sclerosis or a score of 3 for interstitial inflammation, fibrosis, or tubular atrophy.[13]

Among patients with kidney length <9 cm, 73.7% had irreversible disease, compared to only 1.6% in those with length e”9 cm ($p < 0.001$). Similarly, no irreversible cases were found with echogenicity < liver, while 20.8% of those with echogenicity e” liver showed irreversible changes ($p < 0.001$). When both sonographic criteria: length <9 cm and echogenicity e” liver—were combined, the predictive value improved, with 77.8% of such cases confirming irreversible disease.

Most importantly, the combined use of kidney length <9 cm and echogenicity e” liver yielded strong diagnostic accuracy: sensitivity 93.3%, specificity 94.0%, PPV 77.8%, NPV 98.4%, and overall accuracy 93.9%. This was superior to using echogenicity alone, which, despite 100% sensitivity, had poor specificity (14.9%) and low

accuracy (30.5%). These findings suggest that while echogenicity is useful for ruling out disease, combining it with renal length provides more precise prediction. Our findings are in line with Moghazi et al.[13], who reported 86% detection of severe CKD using combined renal length and echogenicity thresholds. Araujo et al.[9] and Liborio et al. [8] also highlighted the diagnostic strength of combining these parameters. However, echogenicity alone may result in false positives, as it can increase in both acute and chronic conditions.[7] These results support ultrasonography as a practical, non-invasive, and accessible method to assess renal pathology. In settings where biopsy is risky or unavailable, sonographic markers—particularly renal length and echogenicity—can guide clinical decision-making, stratify patients by risk, and potentially reduce the need for invasive procedures.

Conclusion

This study concludes that ultrasonography is an effective, non-invasive tool for predicting irreversible renal parenchymal disease in suspected glomerulonephritis. Increased cortical echogenicity and reduced renal length showed significant correlation with increased severity grading of histopathological changes. Future multicenter studies and use of kidney length-to-height ratio are recommended to enhance accuracy.

References:

1. Kausar S, Fareed F, Fatima K, Jahanzeb Z, ur Rehman H. The Association of Renal Cortical Echogenicity and Length with Serum Creatinine in Patients with Chronic Kidney Disease. Ann King Edward Med Univ. 2023;23(4):356–60.
2. Haq MN, Raaman L, Miah MZI, Gazi EA, Baroi SC. Epidemiological Pattern of Renal Insufficiency among the Patients of Nephrology Unit of Dhaka Medical College Hospital, Dhaka, Bangladesh. Faridpur Med Coll J. 2013;8(2):80–4.
3. Levin A, Stevens PE, Bilous RW, Coresh J, De Francisco AL, De Jong PE, et al. 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 Suppl. 2013;3(1):1–150.
4. Lee JH, Cho MH, Chung SI, Lim SD, Kim KS. Relationship of renal echogenicity with renal pathology and function. Child Kidney Dis. 2017;21(2):47–52.
5. 5.O'Neill WC. Renal relevant radiology: use of ultrasound in kidney disease and nephrology procedures. Clin J Am Soc Nephrol. 2014;9(2):373–81.
6. Chang P, Pelingon EA. Comparative Study of Renal Parenchymal Resistive Index, Ultrasonographic Grading of Renal Parenchymal Echogenicity, Kidney Length, and Estimated Glomerular Filtration Rate Among Chronic Kidney Disease Patients Undergoing. 2024.
7. Manley JA, O'Neill WC. How echogenic is echogenic? Quantitative acoustics of the renal cortex. Am J Kidney Dis. 2001;37(4):706–11.
8. Liborio AB, de Oliveira Neves FM, Torres de Melo CB, Leite TT, de Almeida Leitão R. Quantitative renal echogenicity as a tool for diagnosis of advanced chronic kidney disease in patients with glomerulopathies and no liver disease. Kidney Blood Press Res. 2017;42(4):708–16.
9. Araujo NC, Rebelo MAP, da Silveira Rioja L, Suassuna JHR. Sonographically determined kidney measurements are better able to predict histological changes and a low CKD-EPI eGFR when weighted towards cortical echogenicity. BMC Nephrol. 2020;21(1):1–8.
10. 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.
11. Kodikara I, Gamage DT, Nanayakkara G, Ilayperuma I. Diagnostic performance of renal ultrasonography in detecting chronic kidney disease of various severity. Asian Biomed. 2020;14(5):195–202.

12. Sethi S, D'Agati VD, Nast CC, Fogo AB, De Vriese AS, Markowitz GS, et al. A proposal for standardized grading of chronic changes in native kidney biopsy specimens. Kidney Int. 2017;91(4):787–89.

13. 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(4):1515–20.

14. Jalili J, Khosroshahi HT, Olyaei ASB, Gharebaghi B, Mostafavi S, Zarrintan A, Mirza-Aghazadeh-Attari M. Using Ultra-Sonography in Acute and Chronic Renal Pathologies: A Cross-Sectional Study. Nephro-Urol Mon. 2020;12(1):7–24.

15. Braconnier P, Piskunowicz M, Vakilzadeh N, Müller ME, Zürcher E, Burnier M, Pruijm M. 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):117–27.