SONOGRAPHIC ASSOCIATION OF RENAL PARENCHYMAL DISEASE GRADING WITH AGE AND KIDNEY DIMENSIONS: A CROSS SECTIONAL STUDY

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ABSTRACT

BACKGROUND: Chronic Kidney Disease (CKD) presents a notable worldwide health concern. This study focuses on the sonographic assessment of renal parenchymal disorders using gray-scale ultrasonography, aiming to categorize illnesses based on echogenicity, renal size, and cortical thickness.

OBJECTIVE: This study focuses on the sonographic assessment of renal parenchymal disorders using gray-scale ultrasonography, aiming to categorize illnesses based on echogenicity, renal size, and cortical thickness to enhance clarity.

METHODOLOGY: : During the period from July to December 2023, a cross-sectional study took place at the Radiology Department of the Institute of Kidney Diseases in Peshawar. Data from 293 patients were analyzed, applying descriptive statistics, cross-tabulations, and correlational analyses to explore relationships between age, kidney dimensions, and CKD grading.

RESULTS: The study revealed a mean age of 46.56 years, with the highest CKD frequency in the age group of 41 to 60 years. Echogenicity grading demonstrated 12.97% mild, 25.26% moderate, 60.07% moderately severe, and 1.71% severe CKD cases. Significant correlations were observed between age and kidney dimensions, emphasizing the need for proactive screening.

CONCLUSION: Ultrasound proved effective in detecting renal abnormalities, highlighting increased echogenicity, reduced cortical parenchymal thickness, and diminished renal size, especially prevalent in elderly patients. The study underscores the urgency for enhanced healthcare awareness, particularly in resource-limited rural areas, advocating for proactive screening and early intervention strategies to address renal health challenges.

KEYWORDS: CKD, Echogenicity, Grading, Gray Scale, Renal Parenchymal Disease, Ultrasound

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INTRODUCTION

Chronic Kidney Disease (CKD) ranks as the twelfth leading cause of mortality and the seventeenth leading cause of disability globally. It is a major global public health concern, both in terms of the number of individuals affected and the huge medical expenses involved(1, 2). Kidney ultrasonography has become the most common study in radiology departments. Ultrasonography serves as a noninvasive and cost-effective research method, offering sufficient anatomical information for the identification of renal disorders. Importantly, this diagnostic approach avoids subjecting patients to radiation or contrast, and it has therefore largely supplanted traditional ultrasonography worldwide (3-5). Renal parenchymal diseases are the most prevalent causes of acute and chronic renal diseases, and if not managed and treated effectively, they can progress to end stage renal disease. If these situations develop, they are exceedingly expensive to treat and may be deadly if neglected. The goal of this study is to use ultrasonography to examine the renal alterations associated with renal parenchymal disorders. Sonography can determine renal length, thickness, and echogenicity (Figure 1-5)(6). These details aid in determining the extent of renal parenchymal injury and its reversibility(7), as well as the decision to undertake a renal biopsy (8). An aberrant sonographic finding was found in 67% of CKD cases, according to one investigation(9).

Renal parenchymal disease refers to a group of disorders affecting the renal cortex and medulla. The onset of these issues can stem from congenital, genetic, or acquired factors, and they may result from bacterial and viral infections, kidney stones, hypertension, diabetes, autoimmune disorders, and specific medications (10). All of these factors contribute to the early identification and prediction of abnormalities, which is essential for making an appropriate treatment choice. The aim of this study is to use gray-scale ultrasonography to examine sonographic features in renal parenchymal disorders in order to categorize illnesses.

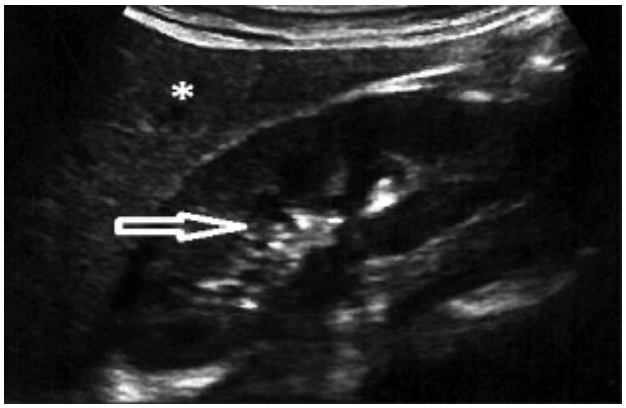

Figure 1 The abdominal ultrasound (longitudinal section) displays the right kidney with normal renal cortical echogenicity, graded as Grade 0. This indicates echogenicity less than that of the liver (marked with a star), while maintaining preserved corticomedullary definition (indicated by an arrow).

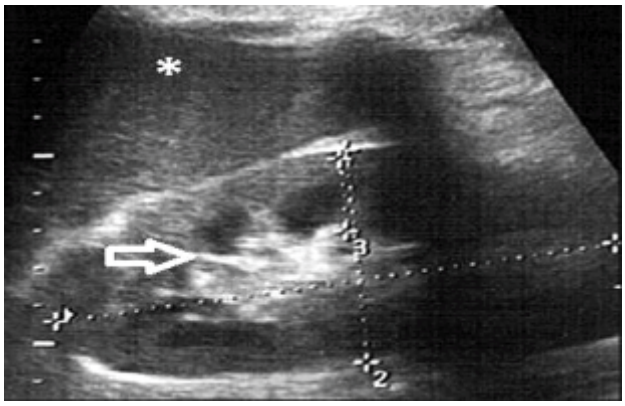

Figure 2 Abdominal section ultrasound reveals Grade 1 renal cortical echogenicity, meaning the right kidney's cortico-medullary definition (arrow) is preserved, and the kidney's echogenicity is the same as that of the liver (star).

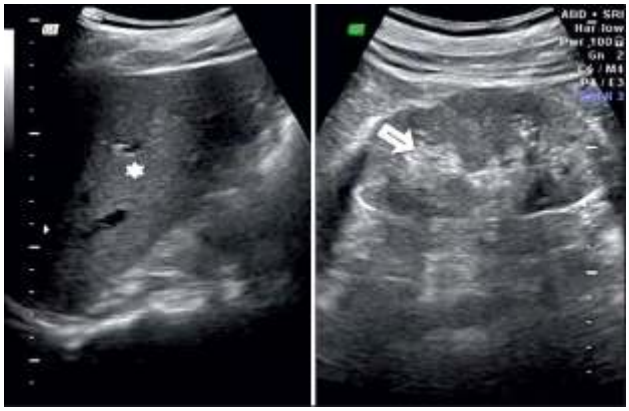

Figure 3 The longitudinal segment of the abdominal ultrasound reveals Grade 2 renal cortical echogenicity, meaning the left kidney's cortico-medullary definition (arrow) is preserved whereas the liver's echogenicity is less.

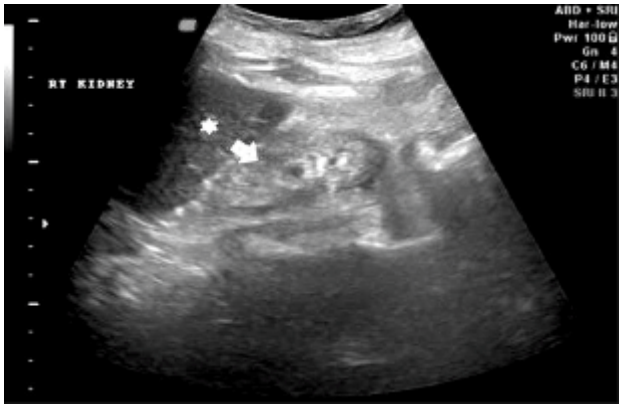

Figure 4 In the longitudinal section of the abdominal ultrasound, the right kidney is observed to have renal cortical echogenicity graded as Grade 3. This signifies that the corticomedullary definition (indicated by an arrow) of the kidney is poorly maintained, and the kidney appears more echogenic than the liver (marked with a star).

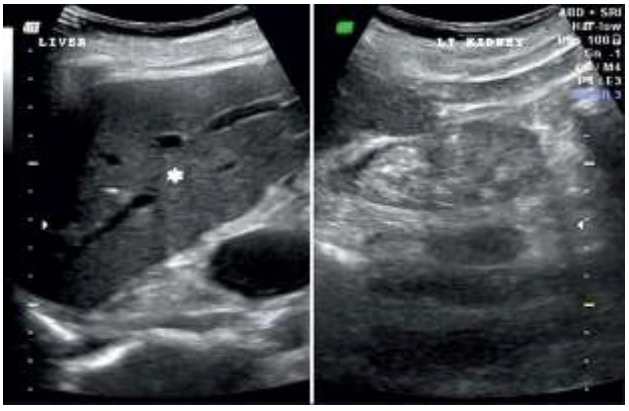

Figure 5 The longitudinal segment of the abdominal ultrasound reveals Grade 4 renal cortical echogenicity, which is characterized by more echogenicity than the liver (star) and a lack of cortico-medullary delineation (arrow) in the left kidney.

METHODOLOGY:

A cross-sectional study was conducted at the Radiology Department of the Institute of Kidney Diseases (IKD) in Peshawar, Pakistan, spanning from June to December 2023. Ethical approval for the study was obtained, with the reference number IKD-2023/RAD/24, issued on June 13, 2023. The sample size was calculated by OpenEpi Version 3, determined based on a prevalence of P. Morbidity at 21.2%(11) with a 5% precision level, was calculated to be 254 using a Convenience sampling technique.

The sample selection for this study comprised individuals of all genders, with a specific focus on those meeting certain criteria. During the ultrasound examination, all measurements were conducted according to a standardized imaging protocol by the same radiologist, who possesses over a decade of experience in vascular ultrasound. The radiologist was blinded to the patients' identities.

Prior to commencing the procedure, patients were instructed to consume three or four glasses of water to facilitate bladder inclusion in the ultrasound scan report. Patients were positioned in the supine posture, with the right upper abdomen generously coated with a coupling agent to ensure a clear connection and prevent artifacts. A 3.5 MHz transducer was utilized for adults, while a 5.0 MHz transducer was employed for children and thin adults.

The procedure commenced by placing the transducer over the right upper abdomen. The beam angle was adjusted as necessary, and the gain was fine-tuned to achieve optimal imaging of the renal parenchyma. The right kidney was best visualized with the patient in the supine position, utilizing the liver as an acoustic window.

Scanning was consistently conducted during deep suspended inspiration, with patients instructed to take a deep breath and hold it. The examination began with a longitudinal scan over the right upper abdomen, followed by a transverse scan. Subsequently, the patient was rotated to the left lateral decubitus position to obtain a coronal view of the right kidney, all kidney dimensions were measures in centimeter (cm). Figure 6 provides an illustration depicting the normal dimensions of the kidney. Chronic kidney disease (CKD) is divided into four classes based on cortical echogenicity (Table 1): Grade 1 for mild form, Grade 2 for moderate form, Grade 3 for severe form, and Grade 4 for end-stage renal disease(12, 13).

Descriptive statistics were applied on continuous variables such as age and kidney dimensions. Cross tabulations were used between age groups, gender and ultrasound grading echogenicity. A correlational analysis was planned to explore the associations between age, and kidney dimensions. Furthermore, an analysis of variance (ANOVA) and post hoc analysis were used to determine the statistical significance of the correlations between these factors. A priori, the P value was fixed at 0.05. Data analytics were performed using IBM SPSS Statistics version 27 software.

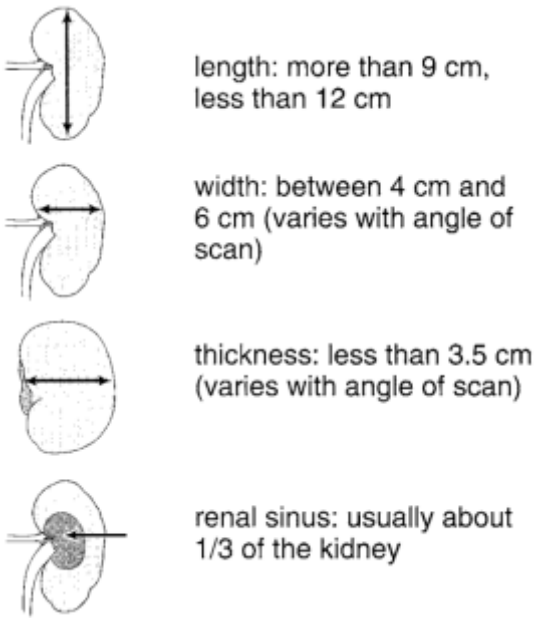

Figure 6: Kidney normal dimensions

Table 1: The echogenicity of the renal cortex is assessed relative to that of the liver and graded accordingly:

Grade 0: Normal echogenicity, less than that of the liver.
Grade 1: Echogenicity equivalent to that of the liver.
Grade 2: Echogenicity greater than that of the liver.
Grade 3: Echogenicity greater than that of the liver with poorly defined corticomedullary borders.
Grade 4: Echogenicity greater than that of the liver with loss of corticomedullary definition.

RESULTS

In our study, we examined data from 293 patients, comprising 146 males and 147 females, with a mean age of 46.56±18.896 years. The age range varied from a minimum of 7 years to a maximum of 95 years. A radiologist recorded the dimensions of both kidneys (see Table 2-3). Based on ultrasound scans, patients were categorized into different grades: 4 in grade 1, 113 in grade 2, 102 in grade 3, and 74 in grade 4. (Table 4).

Table 2: Descriptive Statistics of Gender

Gender					
		Male	**Female**	**Total**	**Percentage**
Age Group (Years)	**1 – 20**	22	16	38	12.97%
	21 - 40	33	41	74	25.26%
	41 - 60	87	89	176	60.07%
	61 - 80	4	1	5	1.71%
Total		**146**	**147**	**293**	**100**

Table 3: Descriptive Statistics of Kidney Dimensions and Age

	Age (years)	RRL	RRW	LRL	LRW
Mean	46.56	8.665	3.887	8.628	3.921
Median	50.00	8.600	4.000	8.500	3.800
Std. Deviation	18.896	1.6999	.9093	1.7528	.9263
Minimum	7	5.2	1.6	3.8	1.9
Maximum	95	16.0	8.0	14.5	7.0

RRL - Right Renal Length, RRW – Right Renal Width, LRL – Left Renal Width, LRW – Left Renal Width
All dimensions were measured in centimeter (cm).

Table 4 Cross Tabulation between Age Group and Ultrasound Grading (Echogenicity)

		Grade 1	Grade 2	Grade 3	Grade 4	Total	Percentage
Age Group (Years)	**1 - 20**	1	14	16	7	38	12.97%
	21 - 40	0	26	21	27	74	25.26%
	41 - 60	3	72	63	38	176	60.07%
	61 - 80	0	1	2	2	5	1.71%
Total		**4**	**113**	**102**	**74**	**293**	**100%**

Table 5. A statistically significant Pearson correlation was observed among variables (Age, RRL, RRW, LRL, and LRW). Notably, Age is weakly positively correlated with RRW (significant at 0.01), LRL (significant at 0.05), and LRW (significant at 0.05), suggesting that as age increases, these measurements tend to increase. Furthermore, strong positive correlations are observed between RRL and RRW, RRL and LRL, RRL and LRW, RRW and LRL, RRW and LRW, and LRL and LRW (all highly significant at 0.01), implying a consistent positive association between these respective pairs of measurements. These findings provide insights into the interrelationships within the dataset, indicating both weak and strong associations between ages and various measurements, as well as substantial connections among the measurements themselves.

Table 5 Correlation between Age and Kidney Dimensions

		Age	RRL	RRW	LRL	LRW
Age	**Pearson Correlation**	1	.112	.186**	.132*	.127*
	Sig. (2-tailed)		.055	.001	.024	.030
	N	293	293	293	293	293
RRL	**Pearson Correlation**	.112	1	.728**	.719**	.541**
	Sig. (2-tailed)	.055		.000	.000	.000
	N	293	293	293	293	293
RRW	**Pearson Correlation**	.186**	.728**	1	.523**	.586**
	Sig. (2-tailed)	.001	.000		.000	.000
	N	293	293	293	293	293
LRL	**Pearson Correlation**	.132*	.719**	.523**	1	.737**
	Sig. (2-tailed)	.024	.000	.000		.000
	N	293	293	293	293	293
LRW	**Pearson Correlation**	.127*	.541**	.586**	.737**	1
	Sig. (2-tailed)	.030	.000	.000	.000	
	N	293	293	293	293	293
****. Correlation is significant at the 0.01 level (2-tailed).**						
***. Correlation is significant at the 0.05 level (2-tailed).**						

RRL - Right Renal Length, RRW – Right Renal Width, LRL – Left Renal Width, LRW – Left Renal Width
All dimensions were measured in centimeter (cm).

DISCUSSION

In our investigation, we found that the participants had a mean age of 46.56 years, ranging from 1 to 80 years. This wide age range suggests susceptibility to Chronic Kidney Disease (CKD) across all age groups. Notably, the age group of 41 to 60 years showed the highest frequency, comprising 60.07% of the cases, while the age group of 61 to 80 years had the least frequent cases, accounting for only 1.71%. This finding aligns with a study by Khadka et al. 2019(14), In their study, where a mean age of 46.39 years (range 20 - 86 years) was observed, it further supports the understanding that Chronic Kidney Disease (CKD) affects individuals across diverse age ranges. They found that the highest frequency of CKD cases occurred in the age group of 31 to 40 years (25%), followed by the age group of 41 to 50 years (20.5%), with the least frequent cases observed in those over 80 years (3%). Furthermore, Singh et al. 2016(15) study reported a mean age of 54.32 years (range 19 - 85 years). Their findings indicated a prevalence of CKD across various age groups, with the age range of 51 to 60 years constituting the most frequent cases at 33%, followed by the age group of 41 to 50 years at 31%. Conversely, the least frequent cases were observed in the age group exceeding 80 years, comprising only 1% of the study population. These consistent observations across multiple studies underscore the importance of recognizing CKD as a health concern affecting individuals of varying age brackets.

In our research, we found that among 38 patients, 12.97% had mild kidney disease (Grade 1), 25.26% had moderate kidney disease (Grade 2), 60.07% had moderately severe kidney disease (Grade 3), and 1.71% had severe kidney disease (Grade 4) according to sonological grading (see Table 4). It's important to note that our study focused on individuals who specifically visited the hospital for chronic kidney issues, as the hospital specializes in kidney diseases. Comparing our findings with a study conducted by Khadka et al. in 2019(14), they observed 32.2% with Grade 1 CKD, 31.5% with Grade 2 CKD, 20% with Grade 3 CKD, and 16% with Grade 4 CKD. Additionally, Singh A et al.'s study aligned with these results, reporting 35% with Grade 1, 42% with Grade 2, 16% with Grade 3, and 7% with Grade 4 echogenicity. Another study by Siddapa et al. in 2016(15) showed that 48.3% had Grade 1 CKD, 35% had Grade 2 CKD, 11.7% had Grade 3 CKD, and 5% had Grade 4 CKD. These variations in results may be attributed to differences in patient populations and the focus of each study.

Based on our findings, it is evident that individuals from Khyber Pakhtunkhwa (KPK), Pakistan, predominantly reside in rural areas with limited financial resources, often falling below the poverty line. In these regions, access to medical facilities is minimal, and healthcare is often provided by non-specialized health technicians who may lack awareness of proper well-being and kidney screening practices.

Due to these challenges, many patients in KPK only seek medical attention when they are facing critical and serious conditions. Typically, they end up coming to specialized hospitals in Peshawar. Unfortunately, by the time they reach these hospitals, they are often diagnosed at Grade 3, indicating a chronic stage of kidney disease. This suggests a pressing need for increased awareness, preventive measures, and improved healthcare accessibility in rural areas to address kidney health issues at an earlier stage.

CONCLUSION

Ultrasound is effective in detecting elevated echogenicity, reduced cortical parenchymal thickness, and diminished renal size, particularly prevalent in elderly patients. This study illuminates the landscape of renal parenchymal disorders in Khyber Pakhtunkhwa, Pakistan, highlighting the prevalence of chronic kidney disease (CKD) and its correlation with age and kidney dimensions. The results underscore the pressing need for heightened healthcare awareness, particularly in resource-limited rural areas. The study reveals a concerning pattern where patients often reach advanced stages, emphasizing the necessity for a shift towards proactive screening and early intervention. Strengthening medical education and accessibility can play a crucial role in addressing challenges, contributing to the overall well-being and management of renal health.

Ethical approval: Ethical approval was granted by the ethical review board, Radiology Department of the Institute of Kidney Diseases (IKD) in Peshawar.

Conflict of interests: None to declare.

Disclosure: None

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Key for Author Contributions:

A. Conception and Planning of the research
B. Acquisition of data/participation in designing methodology
C. Interpretation, analysis and discussion
D. Review of the manuscript