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Original Article

Correlation of Renal Sonographic Findings with Histopathology of Glomerulonephritis

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ABSTRACT

Introduction: *Chronic kidney disease (CKD) is a significant global health problem, affecting around 10% of adults and often leading to end-stage renal disease (ESRD). Glomerulonephritis (GN), the second leading cause of CKD, involves immune-mediated damage to the kidney's glomeruli, causing symptoms like hematuria, proteinuria, and hypertension. Accurate diagnosis, including serum creatinine levels, urine sodium, biomarkers, and ultrasound, is crucial. Kidney biopsies are essential for assessing GN despite risks in advanced stages.* ***Aim of the study:*** *The study aims to correlate renal sonographic parameters with the histopathology of glomerulonephritis.* ***Methods & Materials:*** *This cross-sectional descriptive study was conducted at the Dhaka Medical College Hospital's Department of Nephrology over 18 months, from July 2018 to December 2019, involving 94 renal disease patients selected through purposive sampling.* ***Result:*** *The study population (N=94) had a mean age of 32.16 years (SD ±13.09), with 53.2% aged ≤30 years and 10.6% over 50 years. Gender distribution was nearly equal: 48.9% male and 51.1% female. Most kidney biopsies (97.88%) were performed on the right kidney.* ***Conclusion:*** *The study revealed strong correlations between renal ultrasound findings and histopathological changes in glomerulonephritis patients. Increased cortical echogenicity on ultrasounds was linked to kidney damage indicators, suggesting that non-invasive ultrasound can effectively predict renal tissue damage, aiding early diagnosis and monitoring of disease progression.*

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INTRODUCTION

Chronic kidney disease (CKD) is a major global health issue characterized by the progressive loss of kidney function over time. It affects approximately 10% of the adult population worldwide, contributing significantly to morbidity and mortality, especially in patients who progress to end-stage renal disease (ESRD)[1-3]. Glomerulonephritis (GN) is the second leading cause of CKD, resulting in inflammation and damage to the glomeruli, the filtering units of the kidney[4]. The pathophysiology of GN often involves immune-mediated mechanisms that damage the renal architecture, leading to varying clinical manifestations such as hematuria, proteinuria, and hypertension[5,6]. Data derived from a U.S. Medicare cohort, with an average age of 75 years, revealed that approximately 1.2% of individuals are affected by glomerulonephritis (GN)[7]. The prognosis of this disease is influenced by multiple factors, including the patient's overall health, existing comorbidities, disease severity, and geographical location[8]. Timely and accurate diagnosis, along with the application of appropriate diagnostic techniques to identify the underlying cause of renal failure, is crucial for implementing targeted treatments and interventions, ultimately preventing irreversible kidney damage[9]. A range of methods, such as assessing serum creatinine levels, measuring urine sodium, employing various biomarkers, and conducting ultrasound examinations, are currently utilized to facilitate the diagnosis of this condition[10]. To meet the diagnostic criteria for chronic kidney disease (CKD), key indicators typically include the presence of albuminuria, abnormalities in urinary sediment, electrolyte imbalances, structural abnormalities identified through imaging and biopsy results, as well as an isolated reduction in the glomerular filtration rate (GFR) to below 60 mL/min/1.73 m^2[11]. Among them, histopathological examination through kidney biopsy remains the gold standard in the evaluation of intrinsic renal disease[12]. Renal biopsy assesses the glomeruli, tubules, interstitium, and vessels within the renal parenchyma. The extent of alteration in these components varies with the type and progression of renal disease, making it challenging to determine the underlying origin in advanced stages[13]. In adult glomerular diseases, kidney biopsies are crucial for assessing lesion chronicity, which indicates whether the damage is reversible or treatable. As glomeruli scar, nephron atrophy occurs, and chronic irreversible damage is evaluated based on tubular atrophy and interstitial fibrosis. The "point of no return" concept suggests that extensive scarring signifies the ineffectiveness of immunosuppressive therapy, leading to a consensus against performing biopsies on small kidneys[14]. Renal biopsy is particularly hazardous for kidneys with an eGFR <30 ml/min/1.73 m^2, often yielding insignificant data, yet specific kidney size thresholds for biopsy remain

undefined[15]. Another useful tool for assessing kidney condition is ultrasonography. Sonography is an essential tool in nephrology for not only the diagnosis and management of kidney disease but also for the guidance of invasive procedures[16]. The safety, simplicity and low cost have made sonography an invaluable tool in nephrology. Moreover, sonography is noninvasive and does not use ionizing radiation[15]. However, it is probably underused in the evaluation of renal structural changes for the assessment of chronic renal failure[15]. In addition to visualizing a dilated collecting system, sonography provides information on renal size and the thickness and echogenicity of the cortex. Increased renal parenchymal echogenicity could be used as a predictor of decreased renal function[17]. However, the specific pathologic changes that altered the ultrasonographic parameters have not been studied[18]. With this background, the present study aimed to correlate renal sonographic parameters with the histopathology of glomerulonephritis and to establish thresholds for renal size and echogenicity that could be useful in making clinical decisions about irreversible renal parenchymal disease.

METHODS & MATERIAL

This cross-sectional descriptive study was meticulously designed and executed at the Department of Nephrology, Dhaka Medical College Hospital (DMCH), Dhaka, Bangladesh, over an extensive 18-month period spanning from July 2018 to December 2019. A purposive sampling technique was implemented to recruit a cohort of 94 renal disease patients admitted to the nephrology department. This selection process was conducted with strict adherence to pre-defined inclusion and exclusion criteria, ensuring the validity and representativeness of the study population. Prior to participation, all patients were thoroughly briefed on the study's aims, methodology, and procedures, with written informed consent obtained from each participant. Baseline demographic information was meticulously collected, adhering to stringent confidentiality protocols to safeguard patient data. The study received ethical approval from the institutional ethics review board of DMCH.

Inclusion criteria:

- Patients with acute kidney injury and chronic kidney disease of uncertain origin.
- Adults are presenting with nephrotic syndrome or glomerular proteinuria.
- Individuals diagnosed with nephrotic syndrome.
- Cases of isolated hematuria or low-grade proteinuria accompanied by impaired renal function or evidence of a multisystem disorder.

Exclusion criteria:

- Patients with diagnosed hepatic disease based on clinical and laboratory evaluations.
- Individuals with evidence of coagulation disorders.
- Pregnant women.
- Patients with grossly asymmetric kidneys or congenital anomalies.

Renal ultrasound and biopsy were the primary investigative tools employed to evaluate renal failure. Sonographic imaging of the kidneys was performed using a 5 MHz convex transducer on an ultrasound machine operated by a trained radiologist. Additionally, sonographically guided renal biopsies were performed using a spring-loaded biopsy gun. Four key histopathological features were assessed: glomerular sclerosis, tubular atrophy, interstitial fibrosis, and interstitial inflammation.

Data Collection

A questionnaire was prepared, considering demographic information, relevant history, examination findings, and investigation reports for all the study subjects. Appropriate data were collected using a preformed data collection sheet. These data were analyzed statistically by standard procedure to arrive at a definitive conclusion regarding the research questions.

Statistical Analysis

Data were systematically organized into comprehensive tables and figures, each accompanied by detailed descriptions to ensure clarity. Statistical analyses were conducted using SPSS software (version 22) on a Windows platform. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages to provide a thorough interpretation of the dataset. The Chi-squared test was applied for categorical data, and the t-test was utilized for continuous variables. A p-value of less than 0.05 was considered statistically significant.

RESULT

Table I presents the demographic characteristics of the study population (N=94), with a mean age of 32.16 years (SD ±13.09). The age distribution shows that the majority of participants (53.2%) are between the ages of ≤20 and 30, while the remaining 46.8% are distributed across older age groups, with 10.6% being above 50 years. In terms of gender, the population is almost evenly split, with 48.9% male and 51.1% female participants.

Table – I: Demographical Characteristics of the Study Population (*n*=94)

Age (in years)	Frequency	Percentage
≤20	25	26.60
21-30	25	26.60
31-40	19	20.20
41-50	15	16.00
>50	10	10.60
Mean±SD	32.16±13.09	
Sex		
Male	46	48.90
Female	48	51.10

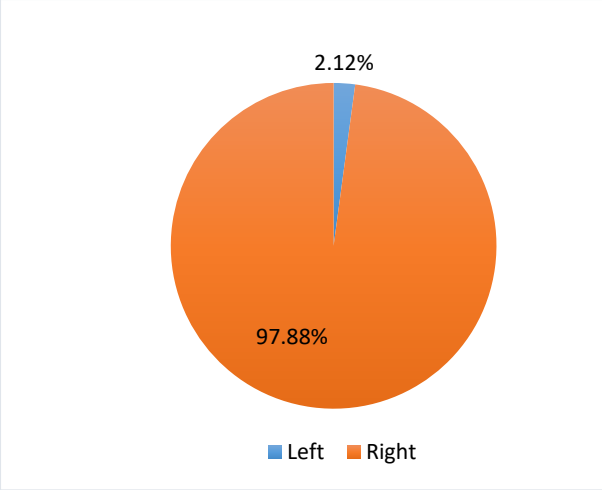

Figure – 1: Side of Involvement

Figure 1 illustrates the distribution of kidney biopsies based on the side of involvement. The majority (97.88%) of biopsies were performed on the right kidney, while only a small proportion (2.12%) were on the left kidney. The most common renal histopathological diagnosis was membranoproliferative glomerulonephritis (21.3%), followed by mesangial proliferative glomerulonephritis (16%), and immunoglobulin A nephropathy (11.7%). Less common conditions included lupus nephritis (9.6%) and diabetic nephropathy (3.2%) (**Table II**).

Table – II: Distribution of the Study Patients by Renal Histopathological Diagnosis (*n*=94)

Diagnosis	Frequency	Percentage
Membranoproliferative glomerulonephritis	20	21.30
Mesangial proliferative glomerulonephritis	15	16.00
Immunoglobulin A nephropathy	11	11.70
Focal segmental glomerulosclerosis	10	10.60
Lupus nephritis	9	9.60
Minimal change disease	6	6.40
Membranous nephropathy	5	5.30
Chronic sclerosing glomerulonephritis	4	4.30
Immunoglobulin M nephropathy	4	4.30
Diabetic nephropathy	3	3.20
Post-infectious glomerulonephritis	2	2.10
Crescentic glomerulonephritis	2	2.10
Interstitial nephritis	2	2.10
Inadequate sample	1	1.10

Renal ultrasound in **Table III** showed that the average kidney length was 9.53±0.78 cm on the right and 9.68±0.74 cm on the left, with similar cortical thickness for both sides (right: 8.54±1.68 mm, left: 8.38±1.06 mm). Cortical echogenicity for the right kidney averaged 23.5±11.54.

Table – III: Renal Sonographic Findings

USG Findings	Right Kidney (*n*=92)	Left Kidney (*n*=2)
	Mean±SD	Mean±SD
Kidney length (cm)	9.53±0.78	9.68±0.74
Mean difference (cm)	-0.15±.22	

Cortical thickness (mm)	8.54±1.68	8.38±1.06
Cortical echogenicity	23.5±11.54	-

In **Table IV** histopathology findings indicated a mean glomerular sclerosis rate of 16.8±28.45, with tubular atrophy, interstitial fibrosis, and inflammation each showing a mean of 15.33±20.44, 15.33±20.42, and 15.33±21.17 highlighting a notable variability in tissue damage across patients.

Table – IV: Renal Histopathology Findings

Histopathology Parameter	Mean±SD
Glomerular sclerosis	16.8±28.45
Tubular atrophy	15.33±20.44
Interstitial fibrosis	15.33±20.42
Interstitial inflammation	15.33±21.17

There were significant associations (p<0.001) between increased right kidney cortical echogenicity and histopathological damage, including glomerular sclerosis, tubular atrophy, interstitial fibrosis, and inflammation, suggesting that sonographic changes strongly correlate with kidney tissue damage (**Table V**).

Table – V: Association Between Cortical Echogenicity of Right Kidney with Renal Histopathological Parameter (n=92)

Histopathological Parameter	p-value
Glomerular sclerosis	0.001
Tubular atrophy	
Interstitial fibrosis	
Interstitial inflammation	

DISCUSSION

Glomerulonephritis (GN) is a group of kidney diseases characterized by inflammation of the glomeruli, the small structures within the kidneys responsible for filtering blood. GN can lead to significant kidney damage, resulting in chronic kidney disease (CKD) or end-stage renal disease (ESRD) if left untreated. Early diagnosis and monitoring of disease progression are crucial for effective management and improving patient outcomes. Renal biopsy remains the gold standard for diagnosing and evaluating the severity of glomerulonephritis by providing direct histopathological insight into the extent of glomerular, tubular, and interstitial damage. However, biopsies are invasive and carry potential risks, making them less desirable in certain clinical situations. As a result, non-invasive imaging modalities, particularly renal ultrasonography, are commonly used to assess renal structure and function in patients suspected of glomerulonephritis. Sonographic parameters, including renal size, cortical thickness, and echogenicity, offer valuable information about renal parenchymal disease and are frequently

employed to evaluate the progression of chronic kidney conditions. This study focuses on correlating renal sonographic findings with histopathological changes in patients with glomerulonephritis. In this study, the demographic analysis of the patients revealed that 26.6% were aged 20 years or younger. The average age of the patients was 32.16±13.09 years. Additionally, the majority of patients were female, making up 51.1% of the sample, while males accounted for 48.9%. In accordance with our study, Dahal et al. reported that the mean age of the participants was 32.4 years [18]. Out of 54 patients, 30(55.56%) were male and 24(44.44%) were female. Male to female ratio was 1.25:1, which is comparable to our study. Although renal sonographic measurements for echogenicity and correlation were primarily taken from the right kidney (97.88%), and biopsies were mostly obtained from the left kidney, it was assumed that the disease affected both kidneys equally. In this study, regarding the distribution of the study patients by renal histopathological diagnosis, it was observed that 20(21.3%) patients had membranoproliferative glomerulonephritis followed by mesangial proliferative glomerulonephritis 15(16%), immunoglobulin A nephropathy 11(11.7%). ***Moghazi et. al.*** noted that among the 207-study population, 55 are proliferative glomerulonephritis, which is consistent with our study as proliferative glomerulonephritis was more common in this study[19]. Regarding the distribution of the study patients by renal USG findings, the mean kidney length was 9.53±0.78 cm in the right kidney and 9.68±0.74 cm in the left kidney. The mean difference between the right and left kidney was -0.15±0.22 cm. The mean cortical thickness was 8.54±1.68 mm in the right kidney and 8.38±1.06 mm in the left kidney. ***Dahal et al.*** reported the mean length of the right kidney was 9.8 cm with a standard deviation of 0.8 cm[18]. For the left kidney, the mean renal length was 10.1cm and a standard deviation of 1 cm. The mean difference in length between the two kidneys was 0.2 cm with a standard deviation of 0.5cm, which was due to the slightly larger left kidney, which is a normal finding. Although there were differences in results between this study and our findings, they are comparable. This variation may be due to geographical and racial variation[20].

Limitations of the Study

The study faces several limitations that could impact its findings. The cross-sectional design limits the ability to determine causal relationships between renal sonographic findings and histopathological changes. The higher frequency of biopsies performed on the right kidney may introduce bias, as kidney diseases can be asymmetrically distributed. Furthermore, the study's reliance on sonographic measurements may lead to subjective variations based on the operator's skill and experience, potentially affecting the consistency and accuracy of the results.

Conclusion and Recommendations

This study found significant correlations between renal sonographic findings and histopathological changes in patients with glomerulonephritis. Increased

cortical echogenicity in renal ultrasounds is strongly correlated with histopathological indicators of kidney damage, including glomerular sclerosis, tubular atrophy, interstitial fibrosis, and inflammation. These results suggest that non-invasive ultrasound can effectively predict the extent of renal tissue damage, offering a valuable tool for early diagnosis and monitoring of disease progression. The findings underscore the importance of integrating sonographic assessments into clinical practice to enhance the management and treatment outcomes for patients with glomerulonephritis.

Conflict of Interest

The authors declare no conflict of interest.

Ethical Approval

The study was approved by the Institutional Ethics Committee.

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