Correlation of Renal Ultrasonographic Parameters with Serum Creatinine in Patients with Chronic Kidney Disease.

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Abstract
Renal ultrasound is used to determine the size, location, architecture of the kidneys, and to exclude obstruction. Echogenic kidneys and renal size may indicate the presence of renal parenchymal disease. Some authors have reported a significant correlation between renal echogenicity and renal function.

A retrospective cross-sectional study carried out in a Tertiary Hospital in Southern Nigeria, using records of CKD patients seen in the renal outpatient clinic. All adults diagnosed with CKD according to KDIGO definition were included; but patients with advanced cystic kidney disease, hydronephrosis, and fatty liver or other liver diseases diagnosed on ultrasonography, were excluded. A data sheet was used to collect information regarding patient's age, sex, anthropometry, aetiology of CKD, and serum creatinine. Glomerular filtration rate was estimated using CKD-EPI calculator. Information on ultrasonographic parameters such as renal length, renal echogenicity, corticomedullary differentiation, were obtained from patient's records and the radiology database.

Out of 102 CKD patients studied, 8.8% had grade 1 echogenicity, while 50% had grade 4. The overall mean serum creatinine was 7.83.5 mg/dl, it was highest among grade 4 group compared to other grades. Serum creatinine increased as grade of renal echogenicity increased (F=4.059, P= <0.001). Renal echogenicity was predictive of serum creatinine (B=2.421, CI=1.800-3.042, p=<0.001).There was a significant negative correlation between left kidney length and serum creatinine (r= -0.235, p=0.018), but there was no correlation between kidney length and grade of echogenicity

Renal echogenicity correlates better with serum creatinine than kidney length in adults CKD patients. The implication of this is that renal ultrasound scan would be a useful bedside technique in renal outpatient clinics and emergencies, to quickly identify presence and severity of renal disease.

Keywords
renal ultrasound, chronic kidney disease, echogenicity.

Introduction
The evaluation of a patient with chronic kidney disease (CKD) is incomplete without ultrasonography. Renal ultrasound can determine the size, location, architecture of the kidneys, and exclude obstruction. Echogenic kidneys indicate the presence of renal
parenchymal disease, however the sizes of the kidneys vary in CKD depending on aetiology. Some authors have reported a significant correlations between renal echogenicity and renal function and structure. Platt et al in 1988, observed no significant correlation between renal echogenicity and renal function, but Siddappa et al reported that renal echogenicity has the strongest positive correlation to serum creatinine, compared to longitudinal renal size and renal volume. The aim of this study is to correlate renal echogenicity with serum creatinine and kidney length, and to determine the significance of renal echogenicity in identifying the progression of CKD.

Methods
This was a retrospective cross-sectional study using records of CKD patients in the renal outpatient clinic at Delta State University Teaching Hospital over a one-year period. All adults diagnosed with CKD according to Kidney Disease Improving Global Outcome (KDIGO) definition were included; but patients with advanced cystic kidney disease, hydronephrosis, and fatty liver or other liver diseases diagnosed on ultrasonography, were excluded. A data sheet was used to collect information regarding patients regarding age, sex, anthropometry, aetiology of CKD, and serum creatinine. Glomerular filtration rate will be estimated using CKD-EPI equation. Information on ultrasonographic parameters such as renal length, renal echogenicity, corticomedullary differentiation, were obtained from patient’s records and the radiology database. The kidney echogenicity was graded as follows. (fig 1-4):

- **Grade 0:** Normal echogenicity less than that of the liver, with maintained corticomedullary definition
- **Grade 1:** Echogenicity the same as that of the liver, with maintained corticomedullary definition
- **Grade 2:** Echogenicity greater than that of the liver, with maintained corticomedullary definition.
**Grade 3:** Echogenicity greater than that of the liver, with poorly maintained corticomedullary definition.

**Grade 4:** Echogenicity greater than that of the liver, with a loss of corticomedullary definition. Those with normal echogenicity (grade 0) were excluded from study.

Data was analyzed using statistical package for social sciences (SPSS) version 22.0 software (SPSS Inc. Chicago, Illinois, USA). One-way ANOVA was used to determine any significant difference in the mean serum creatinine and kidney length across all grades of renal echogenicity. Pearson's correlation was used to determine the correlation between serum creatinine and longitudinal renal size. The frequencies of the grades of renal echogenicity were presented as proportions.

$P$ values less than 0.05 were considered statistically significant.

**Results**

Records of a 102 patients were studied. Mean age was 45.16 years, 69.6% were males (Table 1) with a male to female ratio of 2.3:1. Majority of patients (50%) had grade 4 echogenicity while 8.8% had grade 1 echogenicity (Table 2). The overall mean serum creatinine was 7.83 mg/dl, it was highest among grade 4 group compared to other grades. (Table 2). Serum creatinine increased as renal echogenicity grade increased (F=21.832, $P= <0.001$), see table 2. Post Hoc analysis revealed a significant difference between grade 4 echogenicity, and all other grades, this was greatest between grade 4 and grade 1. (Table 4). Renal echogenicity was predictive of serum creatinine (Linear regression analysis: Table 2: Comparison of Serum Creatinine with Grades of Echogenicity

<table>
<thead>
<tr>
<th>Grade of Echogenicity</th>
<th>n</th>
<th>Mean creatinine (mg/dl)</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>$F$-value</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>3.5</td>
<td>1.5</td>
<td>2.5</td>
<td>5.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>4.7</td>
<td>2.1</td>
<td>2.5</td>
<td>8.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>31</td>
<td>6.7</td>
<td>3.3</td>
<td>3.1</td>
<td>12.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>51</td>
<td>9.5</td>
<td>2.8</td>
<td>3.5</td>
<td>13.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>102</td>
<td>7.8</td>
<td>1.7</td>
<td>2.5</td>
<td>13.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SD=standard deviation, $F$=ANOVA test value, $P$= significance test value.
B=2.421, CI=1.80-3.04, P=<0.001).

Table 3: Comparison of Kidney Length with Grades of Echogenicity

<table>
<thead>
<tr>
<th>Grade of Echogenicity</th>
<th>n (%)</th>
<th>Mean Right Kidney Length (cm)</th>
<th>SD</th>
<th>Mean Left Kidney Length (cm)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9 (89)</td>
<td>10.36</td>
<td>1.48</td>
<td>10.70</td>
<td>1.22</td>
</tr>
<tr>
<td>2</td>
<td>13 (119)</td>
<td>10.01</td>
<td>1.31</td>
<td>10.07</td>
<td>1.36</td>
</tr>
<tr>
<td>3</td>
<td>31 (304)</td>
<td>10.02</td>
<td>1.33</td>
<td>10.37</td>
<td>1.30</td>
</tr>
<tr>
<td>4</td>
<td>51 (504)</td>
<td>9.94</td>
<td>1.36</td>
<td>10.06</td>
<td>1.49</td>
</tr>
</tbody>
</table>

Mean right and left kidney length were 10.17±1.56cm and 10.23±1.55cm respectively, there was no correlation between kidney length and grade of echogenicity (table 3); however there was a negative correlation between kidney length and serum creatinine (r= -0.235, p=0.018 for left kidney, r= -0.195, p=0.052) for the right kidney).

Table 4: Post Hoc Multiple Comparisons of Renal Echogenicity Grades vs. Serum Creatinine

Of patients studied, 27.4% had diabetes mellitus, while 62.6% had hypertension. Mean kidney length was higher in diabetics compared to non-diabetics (10.09 ± 0.89 vs. 8.25 ± 0.623, p= <0.0001), while hypertensive patients had reduced kidney length compared to non-hypertensives (8.98 ± 0.72 vs. 10.97 ± 1.73, p= <0.0001)

Discussion

Early detection and treatment of kidney disease has been advocated as the means of reducing the burden of CKD, which is disproportionately higher in the black race and disadvantaged populations. Renal sonography has the advantages of availability, accessibility, affordability and portability as a marker for detection and monitoring of kidney disease.

This study revealed a significant correlation of renal echogenicity (grade 1 to 4) with serum creatinine, and renal echogenicity was predictive of serum creatinine levels. Similarly, Siddappa et al in India reported a significant positive correlation. The correlation of increasing renal echogenicity with serum creatinine shows that the parameter of ultrasonic renal cortical changes can be used confidently to diagnose the presence of chronic kidney disease though not particularly the cause of the kidney disease. Furthermore, grading of renal echogenicity can be used to extrapolate the extent of kidney damage. Renal ultrasonography has the advantage of being non invasive, non laborious, readily accessible and affordable and can be performed quickly at the patient bedside or at first contact with the patient.

The normal kidney is less echogenic than the liver, and increased renal cortical echogenicity is a typical B-mode ultrasound finding of longstanding severe CKD. Other findings include reduced renal length, reduced renal cortical thickness, loss of the normal corticomedullary differentiation with poor delineation of the of
the renal pyramids and the renal sinus, irregularities of the margins of the kidneys, papillary calcifications, and cysts. This study revealed that grade 1 renal echogenicity correlated with abnormal serum level of 3.5 mg/dl, which is a definite marker of renal disease. Grade 1 corresponds to renal cortical echogenicity that is the same as that of the liver with maintained corticomedullary definition. Saddappa et al similarly reported a mean serum creatinine of 2.8mg/dl in patients with grade 1 echogenicity, however in a much earlier study, Platt et al reported that 72% of the patients in whom renal echogenicity was equal to that of the liver had normal renal function (Grade 1). In the same study however, authors agreed that increasing levels of serum creatinine with increasing grade of renal cortical echogenicity is a specific but insensitive indicator of renal disease. The difference in observation between the current study and the older study by Platt et al, may be explained by the quality of ultrasound machine used, and patient selection.

Renal echogenicity changes as a sonographic parameter for indicating the presence of renal disease was confirmed in a study by Moghazi et al, in which renal biopsy findings were compared with renal echogenicity. The histopathologic findings studied were glomerular sclerosis, tubular atrophy, interstitial fibrosis, and interstitial inflammation; these correlated significantly with renal cortical echogenicity changes however renal length, cortical thickness and parenchymal thickness correlated less strongly with echogenicity. Furthermore, in the same study, severe disease was found to be present in 86% of patients with combined sonographic parameters of reduced renal length and increasing cortical echogenicity (greater than Grade 1). The current study corroborates these findings, as there was no significant relationship between renal length and echogenicity, however serum creatinine increased with reducing kidney length bilaterally.

Majority (80%) of patients in this study had either grade 3 or 4 renal echogenicity, and this probably reflects the late presentation of patients with CKD to nephrologists in Nigeria, in addition the study location is a tertiary referral centre. Only 16.6% of patients were in the elderly age group, again confirming previous reports that CKD is commoner among the young in most developing countries compared to developed countries where CKD is commoner in the elderly. Globally, Hypertension and Diabetes are the leading causes of CKD; hypertension was commoner than diabetes as a cause of CKD among patients studied, and this finding is almost universal across Nigerian and reflects the higher prevalence of hypertension compared to diabetes mellitus in the general population.

CONCLUSION

Renal ultrasonography like the other markers for CKD such as laboratory investigations, and kidney biopsy, is a useful tool for accurately diagnosing CKD. Renal echogenicity correlates better with serum creatinine than kidney length in adult CKD patients. The implication of this is that radiologists should routinely report grade of renal echogenicity, as this correlates more with renal injury and will serve as a useful guide for nephrologists. A portable ultrasound machine should be readily available, and nephrologists trained in basic renal ultrasound.
References


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