SONOGRAPHIC ASSESSMENT OF RENAL SIZES, PARENCHYMAL THICKNESS AND VOLUME IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

BACKGROUND: Ultrasonography can give real time assessment of the kidneys; yet its utility in the evaluation of renal changes during diabetes mellitus illness is rarely reported in Nigeria despite the high burden of diabetes related kidney damage. METHODOLOGY: In this case control study, renal sizes, parenchymal thickness and volume of kidneys of 101 healthy adults and 119 cases with type 2 diabetes mellitus measured by ultrasound during their routine clinic days were compared. All the diabetes cases have normal renal function as measured by their urea and creatinine level. RESULTS: Mean age of adults with type 2 diabetes mellitus (53.81 ± 10.80 years) and control (41.15 ± 13.91 years) groups were significantly different (p < 0.05). Statistical analysis (independent sample T-test) showed significant increase in mean renal width, parenchymal thickness and volume of type 2 diabetes mellitus patients with normal renal function compared to control group (p < 0.05) on the right and left kidney. There was no significant difference in mean renal length and antero-posterior diameter between the two diabetic groups. CONCLUSION: There was a marginal increase in renal width, parenchymal thickness and volume in type 2 diabetes mellitus patients with normal renal function. Ultrasonography therefore provides useful information in detecting renal changes in individuals with type 2 diabetes mellitus.

Key words: Renal sizes, Volume, Parenchymal Thickness, Ultrasonography.

Introduction

Diabetes mellitus is a group of metabolic diseases characterized by hyperglycaemia resulting from defects in insulin secretion, action or both. It is a destructive disease, causing not only ill-health but also affects the economy and psychology of the patient. The prevalence of diabetes mellitus is rising in Nigeria and its complications present an immense public health burden. The diabetes epidemic is centred on type 2 diabetes. This is because it represent > 90% of all cases of diabetes which are increasing rapidly throughout the world. The kidneys as a target organ for secondary microvascular complications of diabetes mellitus represent a health problem of enormous social cost. Diabetic nephropathy is a complication of diabetes. It refers to a characteristics set of structural and functional kidney abnormalities in patients with diabetes. The structural abnormalities include hypertrophy of the kidney, an increase in the thickness of glomerular basement membranes, accumulation of extracellular matrix components in the glomerulus (nodular and diffuse glomerulosclerosis), tubular atrophy, and interstitial fibrosis. While functional alterations include an early increase in the glomerular filtration rate with intra-glomerular hypertension, subsequent proteinuria, systemic hypertension, and eventual loss of renal function. These earlier phenomena of glomerular hyperfiltration, renal hypertrophy and...
renal histological changes that occur in the course of diabetic nephropathy are inconvenient to assess in day to day clinical practice. While renal biopsies are invasive, on the other hand glomerular filtration rate estimations are expensive, cumbersome and not useful for the diagnosis of hypertension; hence the need to have a method for early detection of morphological renal changes for timely intervention. Ultrasonography is one of the methods used to evaluate renal morphology. Though renal ultrasonography is a simple, accurate, affordable and non-invasive imaging test, its utility in the assessment of kidneys in diabetes mellitus patients is not routinely done. While other modalities can be used to determine kidney volume, ultrasound is preferred in most resource poor settings because it is relatively affordable and non-invasive. It is however not clear whether changes in renal sizes could be detected in type 2 diabetes mellitus using ultrasound. This study therefore compared renal length, width, anteroposterior diameter and parenchymal thickness as well as renal volume using ultrasound in type 2 diabetes mellitus patients with normal renal function as measured by urea and creatinine level with those of healthy adults without diabetes mellitus.

Method

Study design and setting
This study was case-control in design. Cases were recruited from the Diabetes Clinic of State Specialist Hospital Gombe, Gombe - State Nigeria, while controls were selected among adults living around the same locality of the respective cases. The hospital is located along Bauchi road, Jekadafari Gombe, North eastern Nigeria.

Study population
One hundred and nineteen (119) patients with type 2 diabetes mellitus were recruited. Patients with type 1 diabetes mellitus, ultrasound findings of obstructive uropathy, ascites and lymphadenopathy were excluded. Controls were apparently healthy subjects who volunteer to participate in the study. Their fasting blood sugar, serum urea and creatinine level were determined through a laboratory test.

Ethical consideration
In line with Helsinki Declaration, approval for this study was obtained from the Human Research Ethics Committee of the Gombe State ministry of health. Also the procedures were explained to the patients and informed consent was obtained from each patient before enrolling into the study. They were also aware of their option to withdraw from the study without losing any of the benefits and healthcare given by the hospital.

Equipments
Cases and healthy controls were examined with a 3.5 MHz curve linear transducer (Siemens, G20, made in Italy). Subject’s height and weight were measured on a calibrated vertical wall and a weighing (bathroom) scale (Model H 89 LT Blue) respectively. Blood urea measured in mmol/litre and creatinine measured in µmol/litre were assessed for all participants in a single laboratory using Cobass C 111.

Ultrasound Procedure
Patients were examined between 0800 and 1100 hours because they presented to the Clinic fasting - a routine criteria for test to determine their fasting blood sugar before they see their physician, and thus cannot be kept for a long time. Patients were positioned in supine positions with the Sonographer sitting on the right side of the patient. Ultrasound probe was then positioned gently on the flank. The right kidney was examined in the supine position through the liver by angling the transducer obliquely. Measurements were taken in longitudinal as well as axial image at the level of hilum in static image. With the patients in the right decubitus, the arm extended over the head and using a coronal approach the left kidney is visualized through the spleen. The decubitus and oblique positions were varied until the kidney is completely seen. The maximum length of the kidney was measured in the longitudinal plane while the width and thickness were measured in the transverse plane perpendicular to the longitudinal axis of the kidney.

Data Analysis
Data were categorized into two (2); Controls and Diabetes mellitus patients with normal renal function. Renal volume was calculated by using the ellipsoid
formula: volume (cm$^3$) = length (cm) x width (cm) x thickness (cm) x 0.523. Body mass index was calculated as BMI (kg/m$^2$) = weight (kg) / height$^2$ (m$^2$).

Mean and standard deviation were used as measures of central tendency. Independent sample t-tests was used to compare the mean of diabetes mellitus patients and controls. Data were analyzed using Statistical Package for Social Sciences (SPSS) Version 20.0. Statistical significance was set at p < 0.05.

### Results

#### Clinical data

One hundred and nineteen (119) patients with confirmed type 2 diabetes mellitus with normal renal function and 101 non-diabetic control subjects participated in this study (Tab. 1). There were more female than male. The total mean age of type 2 diabetes mellitus patients comprising both male and female (53.81 ± 10.80 years) and control group (41.15 ± 13.39 years) were significantly different (p<0.05). However, there was no significant difference in mean heights, weight and body mass index between the two groups (Tab. 1). Table 3 showed the duration of type 2 diabetes mellitus in study group, 42% had diabetes between 1-2 years, 46% had diabetes between 3-4 years while only 12% had been with type 2 diabetes mellitus between 5-6 years.

### Laboratory data

The mean value of urea and creatinine for non diabetic control and diabetes mellitus (DM) patients are shown in (Tab. 1). Mean values of urea and creatinine for males in control subjects are 4.79 ± 0.45 mmol/litre and 99.23 ± 5.56 µmol/litre respectively, while the females have mean values of 3.73 ± 0.64 mmol/litre and 78.04 ± 6.90 µmol/litre respectively for urea and creatinine. On the other hand, the total mean values of urea and creatinine for males with diabetes mellitus are 7.60 ± 0.94 mmol/litre and 70.35 ± 28.06 µmol/litre respectively. Consequently the females with diabetes mellitus have a mean value of 3.38 ± 0.98 mmol/litre for urea and 60.00 ± 16.01 µmol/litre for creatinine.

### Sonographic renal findings

(Tab. 2), compares the mean values of renal sizes, parenchymal thickness and volume between diabetes mellitus patients and controls. Independent Sample T-test indicated significant increase in mean renal width, parenchymal thickness and volume (p < 0.05) of type 2 diabetes mellitus on the right and left compared to control group. In contrast no significant diffe-

### Table 1: Socio-demographic and renal biochemical parameters of diabetes mellitus Patients and controls.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control (n=101)</th>
<th>Type 2 Diabetes Mellitus Patients (n=119)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Male (n=48)</td>
<td>Female (n=53)</td>
<td>Total (n=101)</td>
</tr>
<tr>
<td></td>
<td>46.06 ± 14.98</td>
<td>36.71 ± 11.29</td>
<td>41.15 ± 13.91</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>89.10 ± 13.53</td>
<td>65.79 ± 14.24</td>
<td>67.39 ± 13.94</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.66 ± 0.13</td>
<td>1.59 ± 0.17</td>
<td>1.62 ± 0.15</td>
</tr>
<tr>
<td>B.M.I (kg/m$^2$)</td>
<td>25.06 ± 4.04</td>
<td>27.43 ± 14.39</td>
<td>26.31 ± 10.80</td>
</tr>
<tr>
<td>Urea (mmol/litre)</td>
<td>4.79 ± 0.45</td>
<td>3.73 ± 0.64</td>
<td>4.01 ± 0.57</td>
</tr>
<tr>
<td>Creatinine (µmol/litre)</td>
<td>99.23 ± 5.56</td>
<td>78.04 ± 10.66</td>
<td>89.40 ± 10.86</td>
</tr>
</tbody>
</table>

Normal values: Urea = 3.5-7.1 mmol/litre (male), Creatinine = 71-133 µmol/litre (male)
Urea = 2.6-6.1 mmol/litre (male), Creatinine = 62-106 µmol/litre (female)

#### Table 2: Comparison of Renal sizes, Parenchymal thickness and Volume between Diabetes Mellitus Patients and Healthy controls.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control (n=101)</th>
<th>Diabetes mellitus (n=119)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Kidney: Length (cm)</td>
<td>10.05 ± 0.82</td>
<td>11.14 ± 7.60</td>
<td>0.15</td>
</tr>
<tr>
<td>Left Kidney: Length (cm)</td>
<td>10.29± 0.84</td>
<td>12.29±11.07</td>
<td>0.71</td>
</tr>
<tr>
<td>Right Kidney: Anteroposterior(cm)</td>
<td>4.01 ± 0.50</td>
<td>4.14 ± 0.54</td>
<td>0.06</td>
</tr>
<tr>
<td>Left Kidney: Anteroposterior(cm)</td>
<td>4.09 ± 0.54</td>
<td>4.77 ± 3.95</td>
<td>0.08</td>
</tr>
<tr>
<td>Right Kidney: Width (cm)</td>
<td>4.29 ± 0.75</td>
<td>5.32 ± 0.70</td>
<td>0.00*</td>
</tr>
<tr>
<td>Left Kidney: Width (cm)</td>
<td>4.48 ± 0.68</td>
<td>5.32 ± 0.74</td>
<td>0.00*</td>
</tr>
<tr>
<td>Right Kidney:Parenchymal thickness (cm)</td>
<td>1.87 ± 0.36</td>
<td>2.06 ± 0.66</td>
<td>0.01*</td>
</tr>
<tr>
<td>Left Kidney: Parenchymal thickness (cm)</td>
<td>1.79 ± 0.68</td>
<td>2.15 ± 0.59</td>
<td>0.02*</td>
</tr>
<tr>
<td>Right Kidney:Volume(cm$^3$)</td>
<td>88.40 ± 26.24</td>
<td>121.26 ± 30.82</td>
<td>0.00*</td>
</tr>
<tr>
<td>Left kidney:Volume(cm$^3$)</td>
<td>101.12 ± 30.75</td>
<td>135.5 ± 37.74</td>
<td>0.00*</td>
</tr>
</tbody>
</table>

*Significant difference between groups.

#### Table 3: Duration of type 2 diabetes mellitus in study group

<table>
<thead>
<tr>
<th>Duration</th>
<th>Number of Type 2 diabetes patients</th>
<th>Percentage of type 2 diabetes mellitus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2years</td>
<td>50</td>
<td>42%</td>
</tr>
<tr>
<td>3-4years</td>
<td>55</td>
<td>46%</td>
</tr>
<tr>
<td>5-6years</td>
<td>14</td>
<td>12%</td>
</tr>
</tbody>
</table>
Renal dimensional variations are known to occur in nephropathies due to hypertrophic process. Previous studies have reported increased in kidney size in early stage diabetes mellitus and decrease or increase in renal size is known to be an important sign of renal disease. The present study appear to be the first to utilize ultrasound to assess renal sizes associated with type 2 diabetes mellitus in Nigerian adults to the best of our knowledge. In this study the average renal width, parenchymal thickness and volume of diabetes patients with normal renal function were found to be significantly higher compared with their healthy controls. This finding is consistent with other studies and suggests that type 2 diabetes is characterised by hyperfiltration-induced nephromegaly in the early stage as all of the cases enrolled in this study have diabetes duration of less than 7 years. Renal hypertrophy is a well documented feature of type 1 diabetes mellitus. Although less common, it is also found in type 2 diabetes as reflected in this present study. Previous studies have given the impression that type 2 diabetes is not commonly characterised by nephromegaly. The general argument for this apparent lack of nephromegaly was that the onset of type 2 diabetes cannot be said with accuracy, as it may be preceded by a variable period of asymptomatic hyperglycaemia of 5 to 7 years. During this period the patient may have enlarged kidneys which by the time of detection of diabetes may have regressed to normal size. Secondly, type 2 diabetes is age related and often starts after the forties, usually when the kidneys have suffered the long term consequences of ageing and other recognised promoters of chronic renal injury such as arterial hypertension, obesity or presence of non-diabetic renal disease. However, the result of this present study clearly refutes this argument and shows that diabetic renal hypertrophy can persist for years despite glucose control as reported in other studies. It should be noted also that, studies have suggested renal hypertrophy as a predictor of future progression of diabetic renal disease in type 2 diabetes mellitus.

One factor that might limit the generalization of findings from this study is from the fact that it was difficult to effectively matched cases and control in both their age and height. These factors are an important correlate of renal sizes. However, body mass index as a measure for overweight and obesity in this study was within normal limit and there was no significant difference in height between cases and controls. Similarly, microalbuminuria a biochemical test which can predict glomerular injury in early diabetic nephropathy can be tested by radio immunoassay or by using special deep stick. It is so named because the abnormal albumin in excretion of 30 - 300 mg/hr is below the limits of detection of standard dipsticks and our inability to carry out this biochemical test as predictor for early renal injury in our study group is due to our low resource setting and lack of availability of test materials. This obviously is also a limitation in this study.

Finally though renal changes in parenchyma thickness, length or volume can be associated with disease such as arterial hypertension or be indicative of this, it is very difficult to predict that the changes in renal sizes is primarily due to type 2 diabetes mellitus since hypertension and diabetes mellitus often occurred together and the former was not put into consideration at the beginning of the study.

Conclusion

This study reveals that changes in renal size (width), parenchymal thickness and volume - characterised by hyperfiltration-induced nephromegaly - are present in early stage type 2 diabetes mellitus and can be detected by using a simple, accurate, affordable and non-invasive imaging modality. This finding, therefore provide the basis for routine use of ultrasound in the evaluation of renal morphology in patients with type 2 diabetes mellitus. In these patients, ultrasonography not only helps to exclude obstructive renal disease but also gives useful data on the progression of diabetic renal disease. If physician can discover early diabetic renal complication in the form of nephropathy and modify factors affecting its progression, then its progression can be discontinued.
References


