ORIGINAL ARTICLE

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

Joseph Dlama Zira

Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH), Bauchi, Nigeria.

PJR July - September 2017; 27(3): 213-218

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 ± 13.91years) 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.[1] It is a destructive disease, causing not only ill-health but also affects the economy and psychology of the patient.[2] The prevalence of diabetes mellitus is rising in Nigeria and its complications present an immense public health burden.[3] 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.[4]

The kidneys as a target organ for secondary micro vascular complications of diabetes mellitus represent a health problem of enormous social cost.[5] Diabetic nephropathy is a complication of diabetes. It refers to a characteristics set of structural and functional kidney abnormalities in patients with diabetes.[6] 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.[7,8] 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.[9] These earlier phenomena of glomerular hyperfiltration,[10,11] renal hypertrophy[12] and

Correspondence : Joseph Dlama Zira
Department of Radiology,
Abubakar Tafawa Balewa University
Teaching Hospital (ATBUTH), Bauchi, Nigeria.
Email: josephdlama@gmail.com

Submitted 6 March 2017, Accepted 8 April 2017

renal histological changes[13] that occur in the course of diabetic nephropathy are inconvenient to assess in day to day clinical practise.[14] While renal biopsies are invasive, on the other hand glomerular filtration rate estimations are expensive, cumbersome and not useful for the diagnosis of hypertrophy;[15,16] 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,[17] 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,[18,19] ultrasound is preferred in most resource poor settings because it is relatively affordable and non-invasive.[20] It is however not clear whether changes in renal sizes could bedetected in type 2 diabetes mellitus using ultrasound. This study therefore compared renal length, width, antero posterior 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.[22] Measurements were taken in longitudinal as well as axial image at the level of hilum in static image.[23] 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.[24]

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.[18] 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 analysed 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 patientscomprising 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.

Para-meter	Control (n=101)			Type 2 Diabetes Mellitus patients (n=119)			P-value
	Male (n=48)	Female (n=53)	Total (n=101)	Male (n=44)	Female (n=75)	Total (n=119)	
Age (years)	46.06 ± 14.98	36.71 ± 11.28	41.15 ± 13.91	54.65 ± 12.38	53.32 ± 9.82	53.81 ± 10.80	0.00*
Weight (kg)	69.10 ± 13.53	65.79 ± 14.24	67.36 ± 13.94	66.88 ± 12.03	65.85 ± 14.20	66.23 ± 13.39	0.54
Height (m)	1.65 ± 0.13	1.59 ± 0.17	1.62 ± 0.15	1.68 ± 0.10	1.59 ± 0.99	1.62 ± 0.10	0.89
B.M.I (kg/m2)	25.06 ± 4.04	27.43 ± 14.39	26.31 ± 10.80	23.73 ± 4.36	25.00 ± 3.04	25.04 ± 5.84	0.27
Urea (mmol/litre)	4.79 ± 0.45	3.73 ± 0.64	4.01 ± 0.57	7.80 ± 0.94	3.38 ± 0.98	3.52 ± 1.27	0.00*
Creatinine (µmol/litre)	99.23 ± 5.56	78.04 ± 6.90	89.40 ± 10.66	70.35 ± 28.08	60.00 ± 16.01	63.84 ± 22.09	0.00*

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

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 7.80 ± 0.94 mmol/litre and 70.35 ± 28.08 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-

Parameter	Control (n=101)	Diabetes mellitus (n=119)	P-value
Right Kidney: Length (cm)	10.05 ± 0.82	11.14 ± 7.60	0.15
Left Kidney: Length (cm)	10.29± 0.84	12.29 ±11.07	0.71
Right Kidney:Anteroposterior(cm)	4.01 ± 0.50	4.14 ± 0.54	0.06
Left Kidney: Anteroposterior (cm)	4.09 ± 0.54	4.77 ± 3.95	0.08
Right Kidney: Width (cm)	4.29 ± 0.75	5.32 ± 0.70	0.00*
Left kidney: Width (cm)	4.48 ± 0.68	5.32 ± 0.74	0.00*
RightKidney:Parenchymal thickness (cm)	1.67 ± 0.36	2.08 ± 0.66	0.01*
Left kidney: Parenchymal thickness (cm)	1.79. ± 0.68	2.15 ± 0.59	0.02*
Right Kidney:Volume(cm^3)	88.40 ± 26.24	121.26 ± 30.82	0.00*
Left kidney (cm^3): Volume(cm^3)	101.12 ± 30.75	135.5 ±37.74	0.00*

*Significant difference between groups.

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

Duration	Number of Type 2 diabetes patients	Percentage of type 2 diabetes mellitus
1-2years	50	42%
3- 4years	55	46%
5-6years	14	12%

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

rence was observed in mean renal length and antero-posterior diameter between control and diabetes mellitus group on the right and left kidney.

Discussion

Renal dimensional variations are known to occur in nephropathies due to hypertrophic process.[24] Previous studies have reported increased in kidney size in early stage diabetes mellitus[25] and decrease or increase in renal size is known to be an important sign of renal disease.[26] 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 highercompared with their healthy controls. This finding is consistent with other studies[27] and suggests that type 2 diabetes is characterised byhyperfiltration-induced nephromegaly in the early stage as all of the cases enrolled in this study have diabetes duration of less than 7 years.

Renal hypertrophyis a well documented feature of type 1 diabetes mellitus.[28] Although less common,[29] it is also found in type 2 diabetes[30] as reflected in this present study. Previous studies have given the impression that type 2 diabetes is not commonly characterised by nephromegaly.[31,32] 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.[28] 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.[27,33] 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.[34,35] 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 predicts glomerular injury in early diabetic nephropathy[36] can be tested by radio immunoassay or by using special deep stick. It is so named because the abnormal albumin 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,[37] 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[38] 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

1. Pradeep KD. Renal function in diabetic nephropathy.World JDiabetes 2010; **1:** 48-56.

2. Ala M, Abd E, Osman H, Elzaki A, Elrahim E. Ultrasonographic renal size in individuals with known diabetes mellitus. Sch J app medsci 2013; **1:** 690-92.

3. Sunny C, Ekene Y. State of diabetes care in Nigeria: A Review. Nig Health J 2011; **11:** 101-06.

4. Valeriya L, Markku L. Genetic screening for the risk of type 2 diabetes. Diab car 2013; **36:** 5120-6.

5. Mauer SM, Steffes MW, Brown DM. The kidney in diabetes.Ame J Med 1981; **70:** 603-12.

6. Reeves WB, Andreoli TE. Transforming growth factor b contributes to progressive diabetic nephropathy. Proc Nat Acad Sci 2000; **97:** 7667-69.

7. Mauer S, Steffes M, Ellis E, Sutherland D, Brown D, Goetz F. Renal interstitial expansion in insulin-dependent diabetes mellitus. J ClinInves 1984; **74:** 1143-55.

8. Ueno M, Kawashima S, Nihsi S, Shimada S, Shimada N, Karasawa R, et al.Tubulointerstitial lesions in non-insulin dependent diabetes mellitus. Kid Inter 1997; **52:** 191-4.

9. Hostetter T H, Troy J L, Brenner BM. Glomerular hemodynamics in experimental diabetes mellitus. Kid Inter 1981; **19:** 410-5.

10. Mogensen CE. Early glomerular filtration in insulin-dependent diabetesand late nephropathy.Scand J Clin Lab Invest 1986; **46:** 201-6.

11. Premaratne E, McIsaac RJ, Tsalamandris C, Panagiotopoulos S, Smith T, Jerums G. Renal hyperfiltration in type 2 diabetes: effect of age-related decline in glomerular filtration rate.Diab 2005; **48:** 2486-93.

12. Kleinman KS, Fine LG. Prognostic implications of renal hypertrophy in diabetes mellitus.DiabMetab Rev 1988; **4:** 179-89.

13. Fioretto P, Caramori ML, Mauer M. The kidney in diabetes: dynamic pathways of injury and repair. Diab 2008; **51:** 1347-55.

14. Vincent R, Magalie G, Catherine L, François L, Michel M, Christelle R, et al. Large kidneys predict poor renal outcome in subjects with diabetes and chronic kidney disease. Nephrol 2010; **11:** 1471-2369.

15. Ibrahim H, Mondress M, Tello A, Fan Y, Koopmeiners J, Thomas W. AnAlternative formula to the Cockcroft-Gault and the modification of diet in renal diseases formulas in predicting GFR in individuals with type 1 diabetes.J Am Soc Nephrol 2005; **16:** 1051-60.

16. Chudleigh RA, Dunseath G, Evans W, Harvey JN, Evans P, Ollerton R, et al. How reliable is estimation of glomerular filtration rate at diagnosis of type 2 diabetes? Diab Car 2007; **30:** 300-5.

17. Saddig D J, Naglaa M A, Ibrahim AA, Hashim R F, Hammad H E. Evaluation of Renal Disorders in Type 2 Diabetic Patients Using Ultrasonography. J Med Imag 2013; **3:** 165-170

18. Bakker J, Olree M, Kaatee R, de Lange EE, Moons KG, Beutler JJ, et al.Renal volume measurements: accuracy and repeatability of US compared with that of MR imaging. Radiol 1999; **211:** 623-8.

19. Cheong B, Muthupillai R, Rubin MF, Flamm SD. Normal values for renalLength and volume as measured by magnetic resonance imaging. Clin J Am SocNephrol 2007; **2:** 38-45.

20. Omolola M A, Adebola E O, Ademola J A, Olusegun O A. Ultrasonographic renal sizes, cortical thickness and volume in Nigerian children with acute falciparum malaria. Mal J 2013; **12:** 1475-2875.

21. Sugam S, Prajwal R, Bibek P, Manoy S, Prashant R, Manorayan S, Binod K. Serum urea and Creatinine in Diabetic and Non diabetic subjects. JNepAssoc Med Lab Sci 2008; **1:** 11-12.

22. Roger, C.S. Clinical Sonography-A practical guide. 3rd ed. Lippincott: Williams and Wilkins: 1998.

23. Zeb S, Waseem M, Raza S, Adil S, Iffat Y. Sonographic measurement of renal dimensions in adults and its correlates. InterJ Res Med Pub Health, 2012; **4:** 1-16.

24. Elkin M. Kidney Size - Radiology of the urinary system. Boston: Little Brown and Company: 1980; 1014-32.

25. Tuttle K,Bruton J,Perusek M. Effect of strict acids and renal haemodynamic response to amino acids and renal enlargement in insulin dependent diabetes mellitus. EngJ med 1991; **324:** 1126.

26. Radermacher J. Ultrasonography of the kidney and renal vessels. Normal findings, inherited and parenchymal diseases. Urol 2005; **44:** 1351-63.

27. Agarwal AK, Sumeet S, Umesh G, Rajbala Y, Sanjem M, Arun J. Glomerular filtration rate and total kidney volume in cases of recent Type 2 Diabetes Mellitus. J IndAcadClin Med 2005; **6:** 285-90.

28. Christiansen JS, Gammelgaard J, Trower B, Frandseen M, Urskor H, Parving HH. Kidney function and size in diabetics before and during initial insulin treatment. Kid inter 1981; 20: 451-6.

29. Gragnoli G, Sinnoriri A, Tanganelli I, Fondelli C, Bargogni P, Borgogni L, et al. Prevalence of glomerular hyperfiltration and nephromegaly in normo and microalbuminuric type 2 diabetic patients. Nephro 1993; **65:** 206-11.

30. Wirta O, Pastenack A, Laippala P. Glomerular Filtration Rate and kidney size after six years disease duration in non insulin - dependent diabetic subjects. Clinnephrol 1996; **45:** 10 -17.

31. Heptinstall RH. Pathology of the kidney.Boston; Little Brown and Company.1996: 466.

32. Schuntz A, Hanseen H, Christiansen T. Kidney function in newly diagnosed type 2 (non insulin dependent) diabetic patients, before and during treatment. Diab 1982, **21:** 683-8.

33. Ruggenenti P, Remuzzi G. Nephropathy of type 1 and type 2 diabetes: diverse pathophysiology, some treatment? Nephrol Dial Transplant 2000; **15:** 1900-2.

34. Christensen P, Larsen S, Horn T. Causes of albuminuria in patients with type 2 diabetes without diabetic retinopathy. Kid inter 2000; **58:** 1719 -31.

35. Inomota S. Renal hypertrophy as a prognostic index for the progression of diabetic renal disease in non insulin dependent diabetes mellitus. J diabcompl 1993; **7:** 28-33.

36. Parveen Kumar and Micheal Clark. Kumar and Clark Clinical medicine 5th edition. W.B. Saunders. International Edition.

37. Singh GR, Hoy WE: Kidney volume, blood pressure, and albuminuria: findings in an Australian aboriginal community. Am J Kidney Dis. 2004, **43:** 254-9.

38. Bernard M. Y. Cheung, Chao Li.Diabetes and Hypertension: Is There a Common Metabolic Pathway? Curr Atheroscler Rep (2012); **14:** 160-6.