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The role of renal ultrasound and its correlation with biomarkers in the medical screening of apparently healthy individuals in a Nigerian University

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Abstract

Kidney ultrasound is a noninvasive diagnostic exam that uses images to assess kidney size, shape, location, and blood flow. It uses B-mode imaging for easy renal anatomy assessment and is often used for renal interventions. Clinical laboratory tests assess kidney function, focusing on glomerular filtration rate (GFR) and proteinuria. Serum creatinine is more accurate than urea, but urea is increased earlier in renal disease. Usmanu Danfodiyo University Sokoto (UDUS) students undergo routine pre-admission checks for visual acuity and body mass index (BMI), but kidney sonographic and laboratory investigations are not conducted. Hence, the need for this study. The research aimed at evaluating the sonographic findings of the kidneys and their correlation with biochemical markers among apparently healthy medical students in UDUS. A cross-sectional study was conducted on 50 apparently healthy medical students. Data was collected for sonographic and laboratory investigations and recorded on a data capture sheet. The study found incidental discoveries among the students, despite no symptoms. Laboratory results were normal, possibly due to protein-rich diets and physical activity. Sonographic results were significant compared to biochemical indices, but serum creatinine and right kidney bipolar length with BMI and gender were insignificant. In conclusion, renal ultrasound plays an important role in assessing the kidneys and should be the first line in diagnostic investigation. This study helped in revealing the renal status of the students.

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1. Introduction

The size, position, and form of the kidneys can be evaluated by using images generated by a noninvasive diagnostic procedure called ultrasonography. Blood flow to the kidneys can also be evaluated using ultrasound (US) [1]. B-Mode Kidney ultrasonography

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(US) is a simple method for evaluating the architecture of the kidneys and is also frequently utilized as an image guide for different renal interventional procedures [2]. Pyelonephritis, hydronephrosis, renal calculi, renal cyst, ectopic kidney, renal mass, renal failure, nephrotic syndrome, and renal parenchyma disease (grades I, II, III, and IV) are among the common findings on renal sonography [3]. The most frequent finding, pyelonephritis, was found in 67 cases (40.1%) and was followed by renal parenchymal disease in 35 cases (21.0%) [4].

Investigation and assessment of kidney function can be accomplished with a variety of clinical laboratory tests [2, 5]. Measurements of the glomerular filtration rate (GFR) and the presence of proteinuria are the most practicable clinical diagnostics for evaluating renal function [4, 6]. The glomerular filtration rate is the most reliable general index of glomerular function (GFR) [7]. An adult male's typical GFR ranges from 90 to 120 milliliters per minute [8]. GFR, or blood substance clearance, is the milliliters per minute (mL/min) at which compounds in plasma are filtered by the glomerulus [9]. The body produces creatinine continuously, as a byproduct of creatine phosphate metabolism in muscle tissue. Most of the time, the kidneys obliterate creatinine from the blood [8, 9]. Blood Urea Nitrogen (BUN) containing substance are produced in the liver as a byproduct of the urea cycle and protein breakdown [9]. The kidneys remove around 85% of urea; the gastrointestinal (GI) tract excretes the remaining portion [3, 7, 10]. A rise in urea can also occur in situations unrelated to renal disorders, such as meals high in protein, dehydration, upper gastrointestinal hemorrhage, and catabolic states [11]. Compared to urea, serum creatinine provides a more reliable measure of renal function; nevertheless, urea levels rise early in the course of renal illness [4, 5, 9].

The screening of visual acuity and BMI are the routine pre-admission checkup for the students at the point of admission. However, sonographic and laboratory investigations of the kidney are not carried out on students in UDUS. As such, student with asymptomatic kidney diseases is undetected during the routine screening. Cases of late detection of renal pathologies among medical students that led to deaths has been reported. This research is aimed at investigating the sonographic findings of the kidneys and its relationship with biochemical markers among apparently healthy medical students in UDUS.

2. Materials and methods

This is a cross-sectional randomized study that involves fifty healthy medical students across all departments in UDUS. The study was carried out in Usmanu Danfodiyo University Teaching Hospital Sokoto. Fifty apparently healthy medical students studying at Usmanu Danfodiyo University were recruited for the study. Any Medical students with known history of kidney disorders, non-medical students, apparently healthy medical students from other universities, and healthy medical students who refuse to consent for the study were excluded from the study. Written informed consent was sought and obtained from each of the participants before being recruited into the study. Ethical approval for this study was obtained from Health Research Ethics Committee of the Sokoto State Ministry of Health. A convenient sampling technique was adopted and sample size of fifty was used for the study.

Four ml of venous blood sample was collected into plain container using a disposable vacutainer needle from the medial cubital vein, it was allowed to clot, then centrifuged at 4000 rpm for 5 minutes [12]. The serum was harvested into cryovials and stored at -4 °c until the parameters were assayed. 1.5mL of distilled water was pipetted into a clean tube labelled test and blank [13]. Five hundred (500) uL of sample, 0.5mL of H_2SO_4 and Na_2WO_4 was added into the test, it was mixed and Centrifuge at 4000rpm for 10min [10, 14]. 1.5 mL of the supernatant was pipetted into test tube, and 0,5mL of 0.7N NaOH and picric acid was added, it was mixed thoroughly and incubated at room temperature for 5min [15]. The spectrophotometer was set at 520nm (wavelength) [16]. Reagent blank was used to zero the machine and the absorbance/optical density (OD) of the test and standard was measured and recorded [10]. The kidneys were ultrasonographically examined in longitudinal and transverse scan planes with the transducer placed in the flanks [17] as seen in Figure 1.

3. Results

Among the students who volunteered to be subjects, incidental discoveries were found. Although the students showed no symptoms, the study turned out to be a timely intervention. With few exceptions, the laboratory studies produced normal results. These anomalies may be the consequence of things like eating a diet high in protein and engaging in physical activity. The sonographic results were statistically significant when compared to the biochemical indicators. Sonographic results were compared to biochemical markers with BMI, and the analysis revealed that while the other parameters were significant, the serum creatinine and the right kidney bipolar length with BMI were statistically insignificant. While the other factors were significant, the right kidney bipolar length with gender was statistically insignificant. Tables 1 - 6 show the result of the study in details.

P= value < 0.05 = statistically significant, Rt kd BPL = Right kidney bipolar length, Lt kd BPL =left Kidney bipolar length, BMI = Body mass index, UPCr = Urine protein creatinine ratio, Values on the same column with the same superscript are statistically significant, while those with different superscript on the same column are statistically insignificant.

Table 1. Distribution pattern of participants based on socio demographic parameters.

Variables	Frequency	Percentage (%)
Gender		
Males	33.0	66.0
Females	17.0	34.0
Total	50.0	100.0
BMI		
Normal weight	44	88.0
Over weight	2	4.0
Obese	2	4.0
Under weight	2	4.0
Total	50	100.0
Tribe		
Hausa	32	64.0
Yoruba	4	8.0
Igbo	1	2.0
Others	13	26.0
Total	50	100.0
Department		
DVM	6.0	12.0
MBBS	2.0	4.0
MLS	28	56.0
BNSC	2	4.0
RAD	12	24.0
Total	50	100.0
Stimulants		
Coffee	4	8.0
Fearless	3	6.0
Lipton	20	40.0
Nil	23	46.0
Total	50	100.0

MBBS= Bachelor of Medicine, Bachelor of Surgery, DVM = Doctor of Veterinary Medicine, MLS Medical Laboratory Science, RAD = Radiography, BNSC = Bachelor of Nursing Sciences.

Table 2. Distribution of Morphological pattern of the kidneys among apparently healthy medical students based on sonographic examination.

Features	Right Kidney			Left Kidney		
	Morphology	Freq.	Total	Morphology	Freq.(%)	Total
Void Kidney	-	0 (0)	100	1	1 (2.0)	2
Cyst	5.1/3.4	1(2.0)	2	2.5/2.6	1(2.0)	2
Bipolar length	Normal	50 (100)	100	Normal	50	100
Width	Normal	50 (100)	100	Normal	50	100
Parenchymal Width	Normal	50	100	Normal	50	100
Central sinus echo	Normal	50	100	Normal	50	100
Parenchymal Echogenicity	Normal	50	100	Normal	50	100
Corticomedullary Differentiation	Normal	50	100	Normal	50	100

Figure 1. Sonogram demonstrating right and left kidney.

Table 3. Distribution of the kidney function among apparently healthy medical students in UDUS based on the laboratory investigation.

Parameters	Normal (%)	Above Normal (%)	Total
Plasma creatinine level	47(94)	3 (6)	100
Serum urea level	43(86)	7 (14)	50(100)
UPCr	50(100)	0(0)	50 (100)

UPCr = Urine Protein Creatinine Ratio, % = Percentage distribution

Table 4. Concentrations of Urea, Creatinine and UPCr, BMI and Ultrasonographic patterns of the kidneys among apparently healthy medical students in UDUS.

Parameters	Mean (SD)	T Value	P value
Creatinine (mg/dl)	0.820 (0.421)	92.324	<0.05
Urea (mg/dl)	4.896 (1.426)	89.808	<0.05
UPCr (mg/mmol)	0.784 (0.389)	24.285	<0.05
RT KD BPL(cm)	9.676 (0.741)	13.575	<0.05
LT KD BPL(cm)	9.884 (0.771)	14.258	<0.05
BMI(Kg/m^2)	22.122 (3.140)	49.820	<0.05

T =Test Value P value < 0.05 statistically significant compared to the reference value, BMI = Body mass index, RT KD BPL = Right Kidney Bipolar length, LT KD BPL = Left Kidney Bipolar Length, UPCr = urine protein creatinine ratio.

Table 5. Correlation of sonographic Pattern of the kidney (RTKD BPL, LTKD BPL) with biochemical findings (creatinine, urea, UPCr), BMI, and GENDER.

Parameters	RT KD BPL	LT KD BPL
Creatinine		
R value	0.001	R = 0.120
P value	0.995	P = 0.412
Urea		
R value	R = 0.119	R = -0.091
P value	P = 0.410	P =0.531
UPCr		
R value	R = -0.074	R = 0.123
P value	P = 0.608	P = 0.400
BMI		
R value	R = 0.157	R = 0.210
P value	P = 0.276	P = 0.148
Gender		
R value	R = -0.051	R = 0.321
P value	P = 0.723	P = 0.825

R = Pearson Correlation, P = p value <0.05 statistically significant, UPCr = urine protein Creatinine ratio, BMI = Body mass index, RT KD BPL = right kidney bipolar length, LT KD BPL = left kidney bipolar length.

Table 6. Comparison between serum Urea, Cr, UPCr concentration, sonographic pattern of the kidneys with tribe, BMI and Gender.

Parameters	Rt KD BPL (cm)	Lt KD BPL (cm)	Serum urea (mg/dl)	Serum creatinine (mg/dl)	UPCr (mg/mmol)	BMI kg/m^2
Tribe						
Hausa	9.528±0.706	9.632±0.72	4.632±1.283	0.753±0.411	0.791±0.368	21.891±3.269
Yoruba	10.025±1.229	10.275±0.359	4.250±1.603	0.775±0.500	0.450±0.192	21.773±1.218
Igbo	10.021±	10.300±	3.700±	1.700±	0.400±	33.058±
Others	9.900±0.645	10.331±0.782	5.215±1.737	0.931±0.466	0.900±0.442	21.957±1.445
Total	9.676±0.717	9.884±0.771	4.896±1.426	0.821±0.427	0.784±0.389	22.122±3.139
F = value	1.244	3.464	0.714	2.188	1.779	5.190
P = value	<0.05	<0.05	>0.05	<0.05	<0.05	<0.05
BMI						
Underweight	9.250 ± 0351	9.900 ± 0.141	6.000 ± 1.131	0.950 ± 0.212	0.700 ± 0.565	17.224±.217
Normal	9.705±0.753	9.956±0.768	4.930±1.462	0.816± 0.793	0.710±0.402	21.632±0.256
Overweight	9.250±1.201	8.950±0.071	4.150±0.636	0.600±0.424	0.800±0.141	26.288±.482
Obese	9.900±0.281	10.15±0.212	3.800±0.141	1.000±0.989	0.650±0.141	33.63±3.139
F = Value	0.507	2.219	0.984	0.344	0.113	44.006
P = Value	>0.05	< 0.05	< 0.05	>0.05	>0.05	< 0.05
Gender						
Males	9.703±0.791	9.866±0.8517	4.773±1.229	0.852±0.433	0.800±0.382	21.432±2.267
Females	9.624±0.647	9.918±0.547	5.135±1.764	0.759±0.4184	0.753±0.418	23.461±4.147
Total	9.676±0.741	9.884±0.771	4.896±0.427	0.820±0.427	0.784±0.389	22,122±3.139
F = value	0.127	0.050	0.722	0.523	0.162	5.073
P = value	>0.05	>0.05	<0.04	< 0.05	<0.05	<0.05

4. Discussion

The concentrations of the serum urea, serum creatinine, urine/protein creatinine ratio and the sonographic findings of the kidneys were all statistically significant to the reference values. The correlation between the sonographic findings of the kidneys and biochemical markers revealed positive correlations with the exception of the left kidney bipolar length and the urea level, the right kidney bipolar length and the urine protein creatinine ratio, right kidney bipolar length and gender. The comparison between the sonographic findings of the kidney and biochemical markers with tribe showed that they were statistically significant except for serum urea and tribe that appeared statistically insignificant. The comparison between the sonographic findings and biochemical markers with BMI showed that the serum creatinine and the right kidney bipolar length with BMI were statistically insignificant while the other parameters were significant. The right kidney bipolar length with the gender was statistically insignificant while the other parameters were significant.

The predominant gender and tribe that participated in this study were male and Hausa respectively, and the Medical Laboratory Science students had the highest percentage in the research. The predominant weight was the category of students that fell in the normal weight distribution. Students who do not take stimulants were predominant. In this study, students with sonographic incidental findings were seen which included students with renal cysts and unilateral kidney with the latter finding subjected to Intravenous Urography for further evaluation. This contrasts the study of Idris *et al*. [4], who sonographically assessed the renal length in apparently healthy students of College of Health Sciences, Bayero University, Kano but did not come across incidental findings. This study also disagrees with a study conducted in Lagos State by Anibor [3], in 2019 who also did not find incidental findings after assessing the kidneys with ultrasound. However, this study is in agreement with Ma'aji *et al*. [18], which revealed the normative values of renal ultrasonographic findings in Northwestern Nigeria. The study is also in disagreement with Obiozor [19], which revealed that there is no positive correlation of renal dimensions with body mass index among healthy adults in south-southern Nigeria [19]. The study is in concordant with Adeela [20] in a study they compared renal dimension among different ethnicities in healthy adults and shows that the renal dimension is different among different ethnicities [20]. The laboratory investigations of the kidneys showed a higher percentage of students with normal findings. However, there are cases of students with values above normal which cannot be categorically stated as pathological. Several factors such as extreme aerobic exercises and consumption of food rich in protein could serve as a factor for this increase in values from the laboratory investigations. This assumption agrees with Kuwabara *et al*. [16], whom conducted a study on the comparison of changes in biochemical markers for skeletal muscle, hepatic metabolism, and renal function after three types of long-distance running. In this study, values of serum creatinine increased after such exercises. This study disagrees with Hassan *et al*. [21], in a study they correlated sonographic renal size with biochemical Indices among apparently healthy pregnant women in north-western Nigeria. The study revealed that there was no statistically significant difference in renal size with biochemical indices but revealed progressive increase in renal size as the pregnancy advances. Finally, the research agrees with that of Sidi *et al*. [22], whom correlate renal Doppler indices with anthropometric variables among apparently healthy adults. The study revealed that there was moderate positive correlation between resistive index and pulsatility index with BMI.

5. Conclusion

The study revealed incidental discoveries among asymptomatic medical students, highlighting the importance of regular health check-ups. It found that the majority of participants had normal kidney function, with only a few exceptions showing elevated serum creatinine and urea levels. Additionally, the sonographic patterns of the kidneys were normal in all participants, with no significant correlations between kidney bipolar length and biochemical markers. However, the study did find significant differences in kidney bipolar length and biochemical markers across different BMI categories, emphasizing the importance of maintaining a healthy weight.

Data availability

The data that support the findings of this study are available on request from the corresponding author, Adamu Yakubu. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

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