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Original Research Article

Ultrasound and Computerized Tomography for Nephrolithiasis Detection

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Abstract: ***Introduction:*** Ultrasound (US) is a non-invasive method used for the diagnosis of urolithiasis. If the size of the stone is <5 mm, it may be difficult to diagnose. This study aimed to compare the accuracy of twinkling artifact (TA) of color Doppler US imaging with unenhanced computed tomography (CT) for detecting urolithiasis <5 mm. ***Material and Method****:* This is a Prospective study involving patients at our center who had USG and CTU for suspected urinary tract calculi over a period of 1 year at Department of Radiology, Shadan Institute of Medical Sciences. A total of 120 patients' USG and CTU were compared for the presence of calculi. Sensitivity, specificity, accuracy, positive predictive value and negative predictive value of USG were calculated with CTU as the gold standard. ***Results:*** From the 120 sets of data collected, 37 calculi were detected on both USG and CTU. The sensitivity and specificity of renal calculi detection on USG were 45% and 78% respectively. The mean size of the renal calculus detected on USG was 5.1 mm ± 3.0 mm and the mean size of the renal calculus not visualized on USG but detected on CTU was 3.2 mm ± 1.6 mm. The sensitivity and specificity of ureteric calculi detection on USG were 28% and 95% respectively. The sensitivity and specificity of urinary bladder calculi detection on USG were 20% and 100% respectively. ***Conclusion:*** Initial ultrasonography was associated with lower cumulative radiation exposure than initial CT, without significant differences in high-risk diagnoses with com-plications, serious adverse events, pain scores, return emergency department visits, or hospitalizations.
Key words: Color Doppler ultrasound, twinkling artifact, unenhanced computed tomography, urolithiasis, Nephrolithiasis, Ultrasound.

INTRODUCTION

Renal calculus is one of the most common concerns of people referring to the emergency centers with a possible occurrence of 12% for men and 6% for women. [1] Accordingly, the most common causes of renal calculus are kidney and urinary tract stones. [2] Urography, ultrasound and computed tomography (CT) scan are used as modalities to diagnose the disease. [3] In addition, CT scan is used as a gold standard for the detection of urolithiasis, [4] but due to the excessive use of this modality and the side effects and risks of using it, low-dose CT protocols are used which may reduce sensitivity in detecting small stones in the kidney and urinary tract.

There are also circumstances in which CT scan is not available, including pregnancy, children, and people who are scared of CT scan. [5] Accordingly, many patients with a history of urolithiasis (kidney stones) need to keep track of their condition and repeated CT scans do not seem to be appropriate for these people. Therefore, it is necessary to look for an alternative method for CT scan. Ultrasound is one of these alternatives which, despite its limitations, have an acceptable sensitivity and specificity in detection of urolithiasis. [6] However, in ultrasound, small stones may not be differentiated from normal kidney tissue or create acoustic shading. Moreover, the stones in the ureter's middle part may not be detected due to intestinal and lipid gases. [7]

Today, technological advances and changes in ultrasound devices and probes have made them high quality and better devices which can be used to detect urolithiasis. Twinkling artifact, which is observed in color Doppler ultrasound, is characterized by rapid changes in the composition of blue and red colors of the ecologically stable structures such as calcification, bone, and stones. It was initially defined by Rahmouni *et al*. in 1996. [8] Although the reason for the development of this artifact is not clear, many studies have investigated its use in increasing the diagnostic accuracy of ultrasound for kidney and urinary tract stones. It is used to detect calcifications in various tissues such as prostate, testicular, kidney, bladder, liver, bile duct, pancreas, breast, and ureter, as well as non-calcified bilirubin stones and irregular hard and reflexive surfaces. [9] Studies suggest that this artifact can increase the sensitivity and specificity of ultrasound in diagnosis of kidney stones. [10] It can also transform the management and treatment of kidney stones. [11]

Many studies have tried to determine the factors influencing the advent of twinkling artifact. Although our knowledge in this area is still limited, the following factors seem to have contributed to the emergence of this artifact:

1. The features of the object being imaged, including its texture, surface, size, and chemical composition.
2. Setting of the ultrasound device.
3. Doppler angle; and 4. The type or generation of the Doppler system.

Despite numerous studies, many data have focused on determining the sensitivity and specificity of the twinkling artifact in the diagnosis of kidney and urinary tract stones. For example, Park *et al*. reported the diagnostic accuracy of this artifact for kidney stones as 86–96%, while Dillman *et al*. [12] reported that the positive predictive value and sensitivity of twinkling artifact is 49% and 55%, respectively. Some have also reported that accuracy of the artifact depends on both the setting of the device and the shape of the stone. It has been argued that this artifact is also observed in many parts of the kidney where no stones exist. Therefore, the present study was conducted to evaluate the diagnostic accuracy of twinkling artifact, in comparison to non-contrast CT scans, for detecting (diagnosing) the kidney and urinary tract stones <5 mm.

MATERIAL AND METHODS

This is a Prospective study involving patients at our center who had USG and CTU for suspected urinary tract calculi over a period of 1 year at Department of Radiology, Shadan Institute of Medical Sciences.

Examination technique

CTU was performed in the Department of Radiology at our center using Siemens CT Somatom Sensation 64 with a dedicated protocol. Patient with full urinary bladder was positioned supine on CT examination table and scanned from the upper abdomen to the symphysis pubis with image reconstructed at 5 mm intervals. No oral or intravenous contrast media was given. Calculus was defined as hyper dense focus in the kidney, ureter and/or bladder. USG was performed using multiple new generation ultrasound scanners (Toshiba, Philips and GE Logic).

Ultrasound included evaluation of the kidneys in multiple anatomic planes and maximum calculus measurement was recorded. Curved-phase array transducers were used with varied transducer frequency depending on the body habitus to optimize both patient penetration and image resolution. Calculus on ultrasound was characteristically demonstrated as highly echogenic focus with distinct posterior acoustic shadowing.

Statistical analysis:

Data was collected from the hospital Integrated Radiology Information System (IRIS) and Picture Archiving and Communication System (PACS). Demographic data including age, sex and ethnicity were collected. A review of the USG and CTU of each patient was done with documentation of the imaging findings including presence or absence of calculus, site (right or left urinary tract or both), location (kidney, ureter or bladder), and calculus size in millimeter. With CTU as the gold standard, sensitivity, specificity, accuracy, positive predictive value and negative predictive value of USG for the detection of calculus at each of the three locations (kidney, ureter and bladder) were calculated. Statistical Package for Social Sciences (SPSS) version 25th was used for statistical analyses.

RESULT

A total of 120 patients were included in the study.

Table 1: Distribution of age groups

Age group	No. of patients	Percentage
25-39 Years	54	45
40-59 Years	39	31
60-79 Years	27	24
Sex		
Male	66	55
Female	54	45

In table 1, the patients were predominantly in the late adulthood and elderly age groups, with 54 patients (45%), 39 patients (31%) and 27 patients (24%) aged between 25-39, 40-59 and 60-79 years old respectively. The mean age was 52 years old. Gender wise distribution, there were maximum no. of patients were 66 males and 54 females.

Table 2: Calculi described as staghorn have been classified as ≥ 10.1 mm

Findings	% Error in USG
True positive	37
True negative	30
False positive	4
False negative	49
Total	**120**

Detection of renal calculi

From the 120 data collected patients, 37 renal calculi were detected on both USG and CTU. There were 4 false positive cases. The sensitivity and specificity of renal calculi detection on ultrasound were 45% and 78% respectively. The positive predictive value (PPV) was 80% and negative predictive value (NPV) was 50%. The accuracy of ultrasound in detecting renal calculi was 60%. Of the 40 renal calculi detected on USG, 24 calculi were measured. The remaining 5 calculi not measured were too small and described as tiny or too large and described as staghorn calculi.

Table 3: Size of detected and undetected renal calculi on USG

Calculus size (mm)	Number detected (%)	Number undetected (%)
≤ 5	14 (35)	24 (80)
5.1 – 10	17 (41)	5 (16)
≥ 10.1	9 (24)	1 (4)
Total	**40 (100)**	**30 (100)**

The majority of calculi detected by USG measured 5.1-10 mm. The minimum, maximum and average size documented was 3.5 mm, 22 mm and 5.1 mm ± 3.0 mm respectively. 40 renal calculus detected and 30 renal calculi were not detected on USG but positive on CTU and 30 findings were true negative. Of the 30 calculi not detected on USG but detected on CTU, 6 were described as tiny and the other 24 were measured on CTU. The majority of calculi not detected by USG measured ≤ 5 mm. The minimum, maximum and average size of calculi that were not detected on USG was 3 mm, 11 mm and 3.2 mm ± 1.6 mm respectively.

Table 4: Detection of ureteric calculi on USG and CTU

USG	**CTU Percentage**		
	Normal	Abnormal	Total
Normal	92	18	110
Abnormal	3	7	10
Total	**95**	**25**	**120**
Detection of urinary bladder calculi on USG and CTU			
USG	**CTU Percentage**		
	Normal	Abnormal	Total
Normal	116	2	118
Abnormal	1	1	2
Total	**117**	**3**	**120**

In table 4, ultrasound detected only 7 of the 18 ureteric calculi that were detected on CTU giving a low sensitivity of 28%. However, it showed a high specificity of 95%. The accuracy of ultrasound in detecting ureteric calculi was 81%. The PPV and NPV were 80% and 50% respectively.

On the other hand, detection of urinary bladder calculi for the detection of urinary bladder calculi, ultrasound achieved 20% sensitivity and 100% specificity. The PPV was 100% with NPV of 98%. The accuracy was 98%.

DISCUSSION

In this study, serum TC, TG, and LDL-L concentrations are significantly higher in hypertensive patients than in normotensive subjects. This is consistent with earlier observations in parts of the world and in other parts of Nigeria. [10] This is unlike the findings of Akintunde [13], Lepira et al. [14] and Kesteloot et al. [15] who reported that the TC, TG, and LDL-C of newly diagnosed hypertensive patients did not differ significantly from that of control subjects, though the newly diagnosed hypertensive tended to have a higher level of LDL-C, TG, TC.

In our study, serum TC concentrations are significantly higher in hypertensive patients than in normotensive sub-jects. This is consistent with earlier observations in parts of the world and in other parts of Nigeria. High levels of serum cholesterol are known to increase the risk of developing macrovascular complications such as coronary heart disease (CHD) and stroke. [14] Many epidemiological studies indicate a progressive increase in CHD risk as the serum TC exceeds 5.0 mmol/L which prompted Lewis [16] to suggest that levels of serum TC in the range 5.0–6.5 mmol/L to be considered undesirable. It is to be noted that there was positive and significant correlation between serum TC and both systolic and diastolic BP in both hypertensive patients and normotensive controls. Similarly, there were statistically significant correlations between serum TC and BMI among both hypertensive and normotensive groups. The hypertensive patients had significantly higher BMI and WHR than the controls. This observation may be due to common risk factors for hypertension, obesity and dyslipidemia as obesity, is known to play a central role in the causation and sustenance of insulin resistance, though our study was a cross-sectional study. The exact pathogen etic mechanisms underlying the CVD risk mediated by dyslipidemia are not fully elucidated, but high levels of serum cholesterol are known to increase the risk of developing macrovascular complications such as coronary heart disease (CHD) and stroke. Epidemiological studies indicate a progressive increase in CHD risk as the serum TC exceeds 5.0 mmol/L. [17] It is thus generally recognized and recommended that treatment of hypertension should, in addition to lowering blood pressure, target correction of dyslipidemia (as well as other CVD risk factors) if present, to reduce over-all CVD risk and increase the cost-effectiveness of therapy.

Isolated low HDL-C was the most common individual lipid abnormality among the study participants especially in the controls among whom it represented 71.4% of all forms of dyslipidemia. Akintunde [11] had earlier reported a similar finding in Osogbo. Odenigbo et al. [18] reported a high rate of low HDL-C among apparently healthy professionals in Asaba, a town which is located in close proximity to Nnewi, our study location. The ATP III guidelines recognize isolated HDL-C as a distinct form of thermogenic dyslipidemia but state that it is not common in the general population. Our data and those of Odenigbo et al. however suggest that isolated low HDL-C may be a relatively common baseline lipid abnormality among the general population in this part of Nigeria and that the presence of hypertension only escalates it. HDL-C can result in endothelial damage and trigger an increase in BP. The exact mechanism by which a low HDL-C increases CVD risk has however not been fully elucidated, though experimental studies suggest a direct role for HDL-C in promoting cholesterol efflux (this is called reverse cholesterol transport) from foam cells in the atherosclerotic plaque depots in blood vessels to the liver for excretion. HDL-C also exhibits potent anti-inflammatory and antioxidant effects that inhibit the atherogenic process. It has additionally been shown that a low HDL-C level correlates with the presence of other atherogenic risk factor (some of which are emerging risk factors not considered separately during prevalence). According to Pavithran et al. [19] alteration in lipid metabolism including a decrease in HDL-C can result in endothelial damage and trigger an increase in blood pressure which may partially account for its strong predictive power for CHD.

It has long been known that a low level of HDL cholesterol is a powerful predictor of increased cardiovascular risk. [20] Eapen et al. [21] showed that male and female patients with low HDL-C levels(<35 mg/dL) and with normal total cholesterol levels have more cardiovascular events (such as heart attacks and unstable chest pain) as compared to their adult counterparts with high HDL-C levels. There is strong epidemiological evidence that low HDL-C is an independent risk factor for CVD [22] with strong suggestions that interventions to increase HDL-cholesterol will yield clinically significant outcome benefits. The Multiple Risk Factor Intervention Trial showed that each decrease in HDL-cholesterol of 1 mg/dL (0.03 mmol/L) was associated with an increase in the risk of coronary heart disease of 2% in men and 3% in women. It has been shown that a 1% reduction in HDL-C is associated with a 2-3% increase in CHD risk. Mounting clinical and experimental evidence show that HDL-Cs exert multiple anti atherogenic and antithrombotic effects that together are consistent with a marked reduction in the risk of a morbid cardiovascular event, supporting an anti-atherogenic role for HDL-cholesterol. [23] In recognition of its status as a CVD risk factor, ATP III recommends that a low HDL-C (≤40 mg/dL which is equivalent to ≤1.04 mmol/L for both men and women) should be a secondary target of therapy aimed at lipid lowering to reduce CVD risk. However several studies have not borne this out. [24]

Hypertension and dyslipidemia are well known to frequently coexist. The coexistence of hypertension and dyslipidemia has multidimensional clinical implications. First, CVD risk is synergistically enhanced and for this reason, both conditions should be treated aggressively. This association has been linked to background central obesity and consequent insulin resistance which are underlying factors that play major roles in the pathogenesis of both hypertension and dyslipidemia. The results of a 7 year follow-up study on Finnish men suggested that dyslipidemia characteristic of the metabolic syndrome predicted the development of hypertension. [25] Halperin et al. [26] had also shown that dyslipidemia in apparently healthy individual's leads to hypertension. Hausmann et al. [27] in their intravascular ultrasound studies demonstrated that patients with low HDL cholesterol and high TG levels have more extensive coronary atheromas than those with an isolated elevation of LDL cholesterol.

Finally, despite the relatively low incidence and burden of coronary heart disease risk factors in black Africans, high-risk groups such as hypertensives may need to be more fully evaluated for lipid abnormalities and therapy initiated early for those found with lipid abnormalities.

Limitations of the Study

Our study has several limitations. One study limitation is the fact that our study did not collect data from all parts of the country and at best it could only be speculated whether observed relationship is similar all over the country. Secondly being a cross-sectional study by design it cannot observe prospectively and thus cannot associate causal relationships between the factors under study. Finally it is a hospital based study and may not truly represent the population at large as the risk profile of those who did not come to hospital may differ from those who did.

CONCLUSION

Initial ultrasonography was associated with lower cumulative radiation exposure than initial CT, without significant differences in high-risk diagnoses with com-plications, serious adverse events, pain scores, return emergency department visits, or hospitalizations.

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