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Original Research Article

Efficiency of Diagnosis of Ureteral and Renal Stones by Diagnosis of Sonographic Diagnostic Signs

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Abstract

Introduction: Kidney stones or urolithiasis is a prevalent form of health disorder affecting nearly 10 to 12% of men and 5 to 6% of women in the western world. The biological procedures of crystal anchorage within urothelium are still unclear. However, the development of calcium oxalate stones on "Randall's plaques" erodes the urothelium forming a nucleus for the deposition of calcium oxalate. The passage of kidney stones through the ureter to bladder is painful. However timely diagnosis of kidney stones prevents any form of permanent damage. Patients are either advised to take medication and drink water or are advised to go for surgery after consulting medical expertise depending upon the situation.

Aims and Objectives: To determine the diagnosis ureteral and renal stones using sonography and its associated signs that are found.

Methodology: To collect information the research was conducted on 100 participants who came to the patient unit of our hospital during the period of six months. This research included patients with urinary stones (renal or ureteral) also. Even, unenhanced spiral “computed tomography” (CT), the "gold standard" for the proof of identity of urinary stones, were used to evaluate all people for the presence of urinary stones. Furthermore, all people were surveyed with plain abdominal radiography.

Results: The researcher conducted this survey among 100 outpatients with urinary stones. To understand this research the research examined the sone with size ≤ 0.4 and > 0.4 is seen as high in renal stones compared to ureteral stones. 58.3% of ≤ 0.4 saw in grayscale US and 95% in twinkling artifact. 100% of >0.4 size stones saw in the twinkling artifact. The overall 67% and 97% of stones saw in grayscale and twinkling artifact respectively.

Conclusion: the study concluded that there was no significant improvement in the results obtained from computed tomography compared to ultrasonography.

Keywords: Urolithiasis, urothelium, ureteral, Randall’s plaques.

Introduction

Kidney stones or urolithiasis is a prevalent form of health disorder affecting nearly 10 to 12% of men and 5 to 6% of women in the western world [1]. Urolithiasis has resulted in an increased morbidity rate and its treatment places an economic burden on society.

Kidney stones (more specifically "urolithiasis" or "nephrolithiasis" are deposits of salts and minerals within the kidney. Kidney stones affect the urinary tract. Concentrated urine results in the crystallization of minerals and results in the formation of hard deposits within ureters forming ureteral stones [4]. The majority of kidney stones are composed of oxalate and calcium. The growth of kidney stones initiates with crystal formation in saturated urine, adhering to urothelium, creating a nidus for stone growth [25]. The biological procedures of crystal anchorage within urothelium are still unclear. However, the development of calcium oxalate stones on "Randall's plaques" erodes the urothelium forming a nucleus for the deposition of calcium oxalate [2]. Recent theories further emphasize the role of "cell surface molecules" either inhibiting or favoring crystal adhesion. Urothelial injury increases the surface expression of the molecules thereby further favoring crystal adhesion [3]. Reduced amount of fluid intake, Hypercalciuria, deactivated VDR variants, Primary hyperparathyroidism, and consumption of high salts are the major risk factors accelerating kidney stone formation.

Based on stone composition, urolithiasis is mainly of four types. Ammonium urate, magnesium, carbonate apatite, and ammonium urate are infection stones while calcium oxalate, uric acid, and phosphate are non-infection stones that result in urolithiasis [5]. Furthermore, 2,8-Dihydroxyadenine, cysteine, and xanthine are the genetic cause and drug stones result in the formation of hard masses within the kidney [4]. Presence of a low amount of citrate and a high amount of oxalate in urine results in the formation of calcium-oxalate stones. Presence of excessive amounts of calcium in urine due to increased calcium absorption from the intestine, and bone results in Hypercalciuria [24]. The presence of excessive amounts of oxalate in the urine causes ulcerative colitis. Abnormal functioning of the urinary system results in the formation of calcium phosphate stones.

Patients are often reported to form a hard mixture of calcium carbonate, phosphate, magnesium, and ammonium (commonly known as struvite). "Urinary tract infection" due to the production of ammonia by bacteria raises the pH of urine, promoting struvite formation within the kidney [6]. Struvite stones are more prevalent in women in comparison to men and often occupy the entire kidney [7]. Struvite stones if left untreated results in loss of normal functioning of the kidney. Protein metabolism results in the formation of uric acid within the kidney. Saturation of urine with uric acid crystals results in formation of uric acid stones. Protein consumption in excessive amounts leads to the formation of "uric acid stones [9]." Rarely forming cystine stones are formed within the kidney, and occur due to cystinuria, a genetic disorder occurring due to the presence of cysteine in urine. Cystine stones form inside the kidney and are transported to the ureter and bladder [8]. The report suggests clinical manifestations of renal and ureteral stones include recurrent infections, pain, hematuria, vomiting, and nausea.

The formation of kidney stones does not cause symptoms. Lodging of renal calculi in ureters blocks urine flow and results in swelling of the kidney and ureter spasm. Patients often experience sharp pain below the ribs, pain in the lower abdomen, and a burning sensation during urination [9]. Other symptoms include the formation of red urine, foul smell, and persistent requirements of urinating, nausea, vomiting, and fever in case of infection. As per the guideline of "EAU (European Association of Urology)" Percutaneous nephrolithotomy, Shockwave lithotripsy, and Ureteroscopy are performed for surgical removal of kidney stones [11].

The passage of kidney stones through the ureter to bladder is painful. However timely diagnosis of kidney stones prevents any form of permanent damage. Patients are either advised to take medication and drink water or are advised to go for surgery after consulting medical expertise depending upon the situation.

Materials and Methods

Study design

A study was conducted on 100 individuals who came to the outpatient department of our hospital. Patients with urinary stones (renal or ureteral) are included in this study. Unenhanced spiral computed tomography (CT), the "gold standard" for the identification of urinary stones, was used to assess all individuals for the existence of urinary stones. Also, all individuals were examined with plain abdominal radiography.

Ultrasound (US) technique: After the CT, US examinations were conducted within 24 hours. One of two skilled radiologists who were blinded to the CT results conducted the US examinations.

The sparkling artefact was found using colour Doppler US using a red-and-blue colour map and power Doppler US using a pink colour map using a defined Doppler technique.

Computed tomography technique: A SomatomPlus 4 device was used for an unenhanced helical CT scan on all of the patients. Transverse helical acquisition with a single breath-hold was made continuously from the kidney's highest point to the bottom of the bladder. Each CT scan was examined by a separate radiologist to check for kidney and ureteral stones.

Inclusion and exclusion criteria

Patients who came to the outpatient department of our hospital who follow the study protocol and give informed consent for the study are included. Patients who provide informed consent for the study are included in the study. Patients with urinary colic and who are above 16 years of age are included in the study.

Patients who did not follow the study protocol did not finish it, or did not provide consent were not included in the study. Pregnant women are also not included in the study.

Statistical Analysis

The study used SPSS 25 for effective analysis. The frequency and percentage forms of qualitative data were used. By using the ANOVA test, associations between qualitative variables were evaluated. The continuous data were expressed as mean±sd while discrete data were expressed as frequency and respective percentage. The level of significance was set at a p-value of 0.05 or lower. If it was thought necessary, results were illustrated graphically.

Ethical approval

The patients were given a thorough explanation of the study by the authors. The patients' permissions have been gotten. The concerned hospital's ethical committee has accepted the study's methodology.

Results

Table 1 shows that there are 100 patients with urinary stones included in the study. The sone with size ≤ 0.4 and > 0.4 is seen as high in renal stones compared to ureteral stones. 58.3% of ≤ 0.4 are seen in grayscale US and 95% in twinkling artifact. 100% of >0.4 size stones are seen in twinkling artifact. The total 67% and 97% stones are seen in gray scale and twinkling artifact respectively.

Table 1: Sharp twinkling artifacts and gray-scale ultrasound (US) artifacts associated with urinary stones based on location and size based on gray-scale ultrasound (US)

Size	Location		Gray-scale US	Twinkling artifact
	Renal	Ureteral		
≤0.4	35	25	35(58.3%)	57(95%)
>0.4	25	15	32(80%)	40(100%)
Total	60	40	67(67%)	97(97%)

The locations of urinary stones that were discovered using gray-scale US and/or a sparkling sign are shown in Table 2 by size (0.4 cm and > 0.4 cm; based on CT size assessment). The sparkling indication was visible in five ureteral stones with a barely audible echo difference. Twinkling sign was present in 21 urinary stones with discrete posterior acoustic shadowing.

Table 2: Urinary stones and grayscale ultrasound twinkling artifacts

	Renal Stones			Ureteral Stones		
Stone size	0.7±0.3cm			0.6±0.4cm		
Echo Difference	Marked (32)	Slight (7)	Indistinct (21)	Marked (22)	Slight (6)	Indistinct (12)
posterior shadowing						
Strong	32	5	0	20	0	0
Weak	0	2	0	2	6	0
Twinkling Artifact			19			11
Strong	32	5		20	0	
Weak	0	2		2	6	

Table 3 shows the stones detected in grayscale and twinkling artifact. 67 stones were detected in grayscale and 97 in the twinkling artifacts.

Table 3: Comparison of grayscale ultrasound with Doppler twinkling artifacts for the detection of urinary stones

	CT features	
	Stone	**No stone**
Gray-scale US	67	33
Twinkling artifact	97	3

Discussion

Nephrolithiasis is considered a common complication within primary care. Patients may either showcase symptoms of hematuria or renal colic while other patients may be asymptomatic for instance vague pain in the abdomen, nausea, urinary frequency, penile or testicular pain, and acute abdominal pain [10]. Clinicians are required to be alert regarding the possibilities of kidney stones and their impact and accordingly undertake diagnostic approaches and therapy for effective management of the disorder. Renal as well as Ureteral stones are common disorders causing renal disorders that require urgent care [12]. Thus, imaging of ureteral stones is crucial. "Non-contrast enhanced computed tomography (NCCT) is a common imaging technique used for suspecting urinary stones due to its high specificity and sensitivity [14]. Increased radiation exposure has resulted in the acceptance of alternative approaches. Ultrasonography (US) is considered an attractive modality for renal stone diagnosis as it is inexpensive and radiation-free.

Ultrasonography is an attractive imaging modality used by clinicians for detecting renal stones. Renal stones detected by the US are hyperechoic. Posterior acoustic shadowing is also observed in renal stone detection by relying upon transducer frequency and stone size. Obstruction of the ureter by renal stones demonstrates signs of hydronephrosis by using the US. Research findings further highlight the absence of urine jet and twinkling artefact on the affected side in case of hydronephrosis [13]. Twinkling artefact is viewed on irregular, rough surfaces causing ultrasound wave reflection. Studies in the context of the efficacy of sonographic imaging for renal stone diagnosis have been conducted on 428 patients [15]. Patients suffering from urolithiasis underwent both NCCT and US tests. Indications of symptoms included hematuria and flank pain. Routine administration in the US was provided to patients for screening urinary tract. Ultrasonography was performed by using "grayscale sonography", with a convex transducer of 3.5MHz. The longest axes in US images were used for determining stone size [16]. Results obtained from the study highlighted that out of 428 patients, NCCT identified 171 stones in nearly 169 patients. Ultrasonography on the other hand detected 98 ureteral stones yielding 57.3% sensitivity and 97.5% specificity. The US was further utilized for the detection of ureteral stones' size and location within the urinary tract. Detection sensitivity was comparatively high in the distal ureter [23]. The detection rate increased with increased stone size. Stones above 5mm showcased high sensitivity of 69.8% and that is below 5mm showcased a 30.9% sensitivity [19]. Several studies have also focused on analyzing the association between the absence or presence of hydronephrosis. The US diagnosed 130 hydronephrosis out of 171 stones diagnosed by NCCT. The US on the other hand detected 89 out of 130 ureteral stones (with hydronephrosis) and 9 out of 41 ureteral stones (without hydronephrosis). Thus indicating ureteral stone detection without any kind of ureteral obstruction by Ultrasonography is a complicated task [18]. NCCT has been considered the top investigation technique for renal stone detection. However, the high radiation of NCCT makes it unsuitable for patients. The US though serves to be an alternative for renal stone detection, study results show specificity and sensitivity of the US are below 50%. However, other studies showcase the specificity and sensitivity of ureteral stones to be 97.5% and 57.3%. Variation in the study results thereby highlights better handling of urologic US leads to improved detection of renal stones. Treatment of Urolithiasis relies upon accurate measurement of ureteral stones [22]. The detection of stone size by the US was almost similar to that of size detected by CT, thus indicating the usefulness of the US undertaking decisions regarding intervention [20]. However, in context to result in variation, it can be stated that the diagnosis of ureteral stones in the US is affected by the stone size, age, and body mass. Improvement in the detection of distal ureteral stones can also rely upon bladder distension [21]. Furthermore, transvaginal US proves to be much more effective in identifying renal stones in the distal ureter in female patients.

Conclusion

The study concluded that there was no significant improvement in the results obtained from computed tomography compared to ultrasonography. The size of the stones was measured using axial CT images and compared to the grayscale US process. The researchers conducted a clustered ROC analysis to determine the success of each method in identifying urinary stones. The findings of the study suggest that ultrasonography is a viable and cost-effective alternative to computed tomography for detecting urinary stones. The study also demonstrated the effectiveness of ultrasonography in identifying kidney stones through its ability to detect hyperechoic stones and posterior acoustic shadowing. The presence of hydronephrosis and absence of a urine jet on the affected side were also highlighted as indicators of obstruction due to urinary stones. The limitations of the study include the cluster structure of the findings, which involved two kidneys and eight places within each patient's ureter and kidney. This made it challenging to obtain consistent imaging findings for each patient. However, the researchers addressed this limitation by conducting a clustered ROC analysis and ensuring that each patient's 16 cluster observations were entered as a single observation.

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