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Prediction of the ureteric stone outcome by CT scan

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Abstract

Background and objective: Urolithiasis is prevalent in both developed and developing countries, which is attributed to changes in lifestyles. Management of ureteric stones is highly dependent on their characteristics such as volume, size, and density which can be determined based on the images obtained from CT scan. The present study was carried out to examine the association between the final outcomes of the stones and different stone parameters specified by CT scan.

Methods: The present prospective cross-sectional study consisted of 100 patients who had been referred to the Radiology Department of Rizgary and Erbil Teaching Hospitals in Erbil, Kurdistan Region, Iraq, over six months in 2019 to undergo abdominal CT scan with clinical suspicion of ureteric stones. All patients underwent non-contrast MDCT scan, and the CT images were evaluated for the presence of ureteric stone, site of the stone, side, diameter in three planes, volume, and density. The outcome of the stone was correlated with each above variables.

Results: Ureteric stones were more prevalent among the young and middle age group (25-64 years) with an approximate male-to-female ratio of 3.34:1. There were significant associations between stone outcomes (i.e. spontaneous passage or need for intervention) and the stone characteristics including volume (P <0.001), density (P <0.001)site (upper, mid and lower ureter) (P = 0.02), anteroposterior diameter (P <0.001), transverse diameter (P = 0.006), and superior inferior diameter (P <0.001).

Conclusion: Upon the significant correlation between the spontaneous passage of ureteric stones and their characteristics (i.e., volume, density, site, anteroposterior diameter, transverse diameter, and superior inferior diameter), it is highly recommended that all patients with urolithiasis undergo CT scan examination in order to make the proper decision regarding stone management.

Keywords: Ureteric stones; CT scan; Stone characteristics; Spontaneous passage.

Introduction

Many people worldwide are suffering from urolithiasis, also called urinary tract stones or urinary calculi, in which crystals aggregate in the urine.[1,2] Research has indicated that there has been an increase in the prevalence of urolithiasis in both developed and developing countries over the past few decades, which has been attributed to obesity caused by changes in lifestyle.[3,4] As the main cause of renal colic-type abdominal pain, ureteric calculi or stones, which are discussed under the broad topic of urolithiasis, refer to those stones that lie inside the ureter, which is the duct through which urine passes from the kidney to the bladder.[5] It has been shown that 5 to 12% of the population will suffer from ureteric calculi during their lifetime, with a recurrence rate of about 50%.[6] It has also been demonstrated that the lifetime prevalence of ureteric stones is relatively high, with an occurrence rate of 7.1% in women and 10.6% in men,[3] and

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this prevalence rate has been reported to be increasing globally.[7] According to the research carried out in Iraq, the prevalence rate of ureteric stones in the Iraqi population was 12.5% in 2006.[8] Diagnosis of urolithiasis is usually conducted by utilizing an unenhanced helical computed tomographic (CT) scan which has been reported to have specificity and sensitivity of approximately 100%.[2] It has been reported that the location and size of the ureteric calculi are the main criteria for specifying the clinical management pathway.[9] It is obvious that bigger stones are more difficult to pass through the ureter; therefore, determining the size of the stones can help with the selection of an appropriate treatment strategy.[5] As a result, for diagnosis of ureteric calculi, multi-detector computed tomography (MDCT) has been proposed, which provides remarkably improved images from cross-sectional (axial) imaging to true 3D images.[10] Despite the numerous methods to determine the stone size, including algorithms, coronal and reconstructed images are still the most widely employed estimation methods for this purpose.[11] Due to the high prevalence of ureteric calculi in Iraq and their negative effect on the quality of life among the patients with urolithiasis, the present study was carried out in order to examine and evaluate the correlation between different stone parameters specified by CT scan and the final outcomes of the stones.

Methods

Using a review of cases, the current prospective cross-sectional study was carried out on a sample of 100 patients from different age groups and both sexes. Using a convenience sampling method, patients were selected from those referred to the Radiology Department at Rizgary and Erbil Teaching hospitals in Erbil, Kurdistan Region-Iraq over six months in 2019 (from January to April). To select the study sample, all of the patients who had been referred to the hospitals and proved to have ureteric stones were included. However, some patients who had indications for surgical intervention due to bilateral or multiple ureteric stones, renal impairment, back pressure effect on the upper tract, and urinary tract infection were excluded from the study. All of the patients underwent non-contrast MDCT scan (16 slice Somatom, Siemens, Germany, 2017), and the images were evaluated in both axial and coronal planes. The stones were analyzed as following; side, site (upper ureter from pelviureteric junction to pelvic brim, mid ureter from pelvic brim to lower aspect of sacroiliac joint, lower ureter from lower aspect of SI joint to the bladder), stone diameters (anteroposterior, transverse and sagittal), volume (anteroposterior x transverse x sagittal x 0.52) and density (hounsfield unit). Each patient was monitored for about six weeks to observe for spontaneous passage after the clinical decision for observation. If no spontaneous passage was achieved, the clinical decision was to have an intervention. Finally, a correlation between each stone variables and the final outcome was figured out. The collected data were fed into a computer and analyzed using the statistical package for the social sciences (version 23.0). For this purpose, student's t-test for two independent samples was used for numerical variables, Chi-square test for association was used to compare proportions. Fisher's exact test was used instead of the Chi square test when the expected count of more than 20% of the cells of the table was less than 5. A *P* value of less than 0.05 was considered a significant level in all statistical tests. In order to take the ethical considerations into account, necessary approval was obtained from the Ethical Committee Hawler Medical University. Also, permission was obtained from the presidency of Rizgary and Erbil Teaching hospitals. In addition, the patients' data anonymity and confidentiality were ensured by keeping them in a safe place and using them only for research purposes in this study. Finally, written or

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verbal consent was obtained from the patients, and they were provided with necessary explanations about the aims, duration, and method of the study.

Results

The final study sample was 100 cases with a mean age of 39.22 (±13.5963) years, age range between 12-71 years with an approximate male:female ratio of 3.34:1 (Table 1). The results of the present study indicated that the side of the ureteric stones (i.e., right and left) had no significant relationship with the outcomes (i.e., spontaneous passage or operation) (*P* = 0.47) (Table 2).

Table 1: Patients' demographic information.

Variable	Frequency (N)	Percentage (%)
Age (years)		
Mean ±SD: 39.22 ± 13.59633, Minimum: 12 , Maximum: 71		
≤ 25	12	(12.0)
26-40	51	(51.0)
41-55	24	(24.0)
≥ 56	13	(13.0)
Sex		
Male	77	(77.0)
Female	23	(23.0)
Residency		
Urban	71	(71.0)
Rural	29	(29.0)
Total	100	(100.0)

Table 2: The correlation between the side of the ureteric stones and the outcome.

Side of the stone	Outcome		Total	*P* value
	Spontaneous passage	Intervention		
Right	29 (50.9)	28 (49.1)	57 (100.0)	0.47
Left	25 (58.1)	18 (41.9)	43 (100.0)	
Total	54 (54.0)	46 (46.0)	100 (100.0)	

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Concerning stone site and outcome, a significant relationship between the site of the ureteric stones (upper third, mid, and lower third) and the outcomes (*P* = 0.02) was observed. Most ureteric stones in the upper third passed spontaneously, followed by those in the lower third. However, the majority of the mid ureteric stones underwent intervention (Table 3). In terms of the correlation between the stone characteristics and the outcomes (i.e., spontaneous passage or need for intervention), the results of the present study demonstrated that there was a significant relationship between stone volume, density, anteroposterior, transverse, and superior inferior diameter (all had *P* <0.05) and the outcome. Most of the stones with a mean volume of 104 mm^3 passed spontaneously, while those with a mean volume of 241 mm3 shifted to intervention (*P* <0.001). Stones with a mean density of 453 and 676 Hounsfield units had spontaneous and non-spontaneous passage, respectively (*P* <0.001). Stones with anteroposterior diameter of 5.3 mm had spontaneous passage versus 7 mm for non-spontaneous passage (*P* <0.001). Stones with a transverse diameter of 5 mm vs. 6.2 mm had spontaneous and non-spontaneous passage, respectively (*P* = 0.006). Stones with a superior inferior diameter of 6.8 mm vs. 8.8 mm had spontaneous and non-spontaneous passage, respectively (*P* <0.001) (Table 4).

Table 3: The correlation between the site of the ureteric stones and the outcome.

Site of stone	Outcome		Total	*P* value
	Spontaneous passage	Intervention		
Upper	16 (64.0)	9 (36.0)	25 (100.0)	0.02
Mid	4 (23.5)	13 (76.5)	17 (100.0)	
Lower	34 (58.6)	24 (41.4)	58 (100.0)	
Total	54 (54.0)	46 (46.0)	100 (100.0)	

Table 4: Correlation between the stone characteristics and the outcomes.

Stone characteristic	Outcome	N	Mean ± Std. Deviation	*P* value
Volume (mm^3)	Spontaneous passage	54	104.224±67.916	<0.001
	Intervention	46	241.100±233.049	
Density (Hounsfield Unit)	Spontaneous passage	54	453.556±174.118	<0.001
	Intervention	46	676.370±258.142	
Anteroposterior diameter (mm)	Spontaneous passage	54	5.363±1.136	<0.001
	Intervention	46	7.013±2.119	
Transverse diameter (mm)	Spontaneous passage	54	5.041±1.521	0.006
	Intervention	46	6.215±2.583	
Superior inferior diameter (mm)	Spontaneous passage	54	6.832±1.925	<0.001
	Intervention	46	8.865±2.615	

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Discussion

The prevalence of ureteric stones among the Iraqi population had been reported to be 12.5% which is relatively high.[8] Moreover, such stones can negatively affect the quality of the patient's life. Therefore, it is highly significant to manage them properly by employing a CT scan and figuring out the relationship between the criteria of such stones and the stone outcomes.[12,13] In the present study, it was observed that the side of ureteric stones had no significant effect on the outcome. Therefore, prediction of spontaneous passage of ureteric stones or the need for intervention cannot be achieved based on the side on which such stones are located. This finding is similar to those of the study carried out by Ahmed et al. (2015), who reported that spontaneous passage of ureteric stones is independent on the side and concluded a non-significant relationship between right/left side stones and their spontaneous passage (P >0.05).[14] However, opposite to this finding, Jendeberg et al. (2017) found that spontaneous passage occurs in ureteral stones located on the Left side significantly more than those on the right side.[15] Sfoungaristos et al. (2012) justified this significant effect of the side of stone on spontaneous passage by referring to the fact that the right ureter adheres to the peritoneum, while the left ureter does not, which leads to the need for operation for passage in the right side ureteric stones.[16] The difference between the results of the present study and those carried out by Ahmed et al. (2015), Jendeberg et al. (2017), and Sfoungaristos et al. (2012) might be due to the different number of patients investigated in these studies.[14-16] In terms of the relationship between the site of the ureteric stones and their spontaneous passage or the need for intervention, the results indicated a significant relationship. Therefore, it was figured out that the site in which ureteric stones are located can predict whether they can pass spontaneously or an intervention is required. This finding is in line with those of the study conducted by Tchey et al. (2011), who reported that the spontaneous passage rate for stones located in different sites is significantly different, such that 25.15% for stones located in the upper ureter, 4.7% for those located in the mid ureter, and 70.15% for those in the lower ureter.[17] According to the present study results, a higher rate of spontaneous passage of ureteric stones was seen in those stones located in the upper third, followed by the lower third and the mid. In line with this finding, Jendeberg et al. (2017) reported similar findings.[15] Therefore, it can be concluded that the site or location of ureteric stones can be utilized as a predictor of their outcome (i.e., the spontaneous passage or need for intervention). Regarding the correlation between the CT analyzed features of the diagnosed stones and the outcomes, the results of the study demonstrated that the volume of the stone was significantly related to the outcomes (P <0.001) (stones with a mean volume of 104+-68mm^3 showed spontaneous passage vs. mean volume of 241+/-mm^3 did not show spontaneous passage). This finding is in good agreement with the results of the study carried out by Zorba et al. (2016), who concluded that spontaneous passage of ureteral stones happens in patients who had significantly lower stone volumes. Therefore, they reported a significant correlation between stone volume and spontaneous passage, such that they observed that patients with the stone volume of 41.2 ± 35.5 mm^3 experienced spontaneous passage.[18] Similarly, Jendeberg et al. (2017) concluded that stone volume plays a significant role in the spontaneous passage or need for surgery.[15] The results also revealed a significant correlation between the stone density, measured by Hounsfield unit,[19]and the final outcomes (P <0.001). The stones that showed spontaneous passage had a mean density of 453+/-174 Hounsfield vs. 676+/-258 for those without

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spontaneous passage. Similarly, Jendeberg et al. (2017) observed that very small or low-density stones did not cause any obstruction and could pass spontaneously.[15] This finding is also in line with the study results conducted by Hada et al. (2018), who referred to stone density as an important factor determining the spontaneous passage of lower ureteric stones.[20] Regarding the association between the final outcomes and the anteroposterior diameter of the ureteric stones, the results demonstrated that there was a highly significant relationship between these two variables *(P* <0.001). Patients with the lowest values of anteroposterior diameter experienced spontaneous passage, while those with higher values of anteroposterior diameter required surgery (5.3mm vs. 7mm). This finding is in good agreement with the results of the investigation carried out by Ongün and Dursun (2019), who similarly reported a significant correlation between spontaneous passage and anteroposterior diameter at a *P* <0.001.[21] The results also revealed a significant association between the transverse diameter of the stone and the outcomes (*P* = 0.006) (5mm vs. 6.2mm for spontaneous vs. non-spontaneous passage, respectively). This finding is in line with the results of the study by Hada et al. (2018), who concluded that patients with a lower transverse diameter of the stone were more likely to experience spontaneous passage.[20] Similar results were also reported by Sfoungaristos et al. (2012).[16] Finally, the results showed a significant relationship between spontaneous passage and superior inferior diameter of the stones, which was obtained from the reconstructed coronal images (*P* <0.001) (6.8mm vs. 8.8mm for spontaneous vs. non-spontaneous passage, respectively). Similar results were reported in the study carried out by Bourdoumis et al. (2012).[22] The present study involved some limitations. Firstly, the sample size was relatively small, limiting the generalizability of the present study results. Secondly, the study participants were selected non-randomly, which also restricts the generalizability of the results.

Conclusion

The side of ureteric stones cannot be used to predict their outcome, while the stone site (upper third, lower third, and midthird, respectively) is a significant predictor of spontaneous passage or the need for intervention. Moreover, the outcome of ureteric stones can be predicted by stone characteristics such as volume, density, anteroposterior diameter, transverse diameter, and superior inferiordiameter.

Competing interests

The authors declare no competing interests.

References

1. Parmar MS. Kidney stones. BMJ 2004; 328 (7453):1420–4.
2. Andrabi Y, Patino M, Das CJ, Eisner B, Sahani DV, Kambadakone A. Advances in CT imaging for urolithiasis. Indian J Urol 2015; 31(3):185–93.
3. Scales CD, Smith AC, Hanley JM, Saigal CS. Urologic Diseases in America Project. Prevalence of kidney stones in the United States. Eur Urol 2012; 62:160–5.
4. Neisius A, Preminger GM. Stones in 2012: Epidemiology, prevention and redefining therapeutic standards. Nat Rev Urol 2013; 10:75 –7.
5. Barnela SR, Soni SS, Saboo SS, Bhansali AS. Medical management of renal stone. Indian J Endocrinol Metab 2012; 16(2):236–9.
6. Alelign T, Petros B. Kidney Stone Disease: An Update on Current Concepts. Adv Urol 2018; 2018:3068365.
7. Knoll T. Epidemiology, pathogenesis and pathophysiology of urolithiasis. Eur Urol Suppl 2010; 9(12):802–6.
8. Qaader DS, Yousif SY, Mahdi LK. Prevalence and etiology of urinary stones in hospitalized patients in Baghdad. Eastern Mediterranean Health Journal 2006; 12(12):851–63.
9. Ordon M, Andonian S, Blew B, Schuler T, Chew B, Pace KT. CUA Guideline: Management of ureteral calculi. Can Urol Assoc J 2015; 9(11-12):E837–51.
10. Brisbane W, Bailey MR, Sorensen MD. An overview of kidney stone imaging techniques. Nat Rev Urol 2016; 13(11):654–62.
11. Moon YJ, Kim HW, Kim JB, Kim HJ, Chang YS. Distribution of ureteral stones and factors affecting their location and expulsion in patients

with renal colic. Korean J Urol 2015; 56(10):717–21.
12. Eisner BH, McQuaid JW, Hyams E, Matlaga BR. Nephrolithiasis: What surgeons need to know. AJR Am J Roentgenol 2011; 196:1274–8.
13. Kambadakone AR, Eisner BH, Catalano OA, Sahani DV. New and evolving concepts in the imaging and management of urolithiasis: Urologists' perspective. Radiographics 2010; 30:603–23.
14. Ahmed AF, Gabr AH, Emara AA, Ali M, Abdel-Aziz AS, Alshahrani S. Factors predicting the spontaneous passage of a ureteric calculus of <10 mm. Arab J Urol 2015; 13(2):84–90.
15. Jendeberg J, Geijer H, Alshamari M, Cierzniak B, Lidén M. Size matters: The width and location of a ureteral stone accurately predict the chance of spontaneous passage. Eur Radiol 2017; 27(11):4775–85.
16. Sfoungaristos S, Kavouras A, Perimenis P. Predictors for spontaneous stone passage in patients with renal colic secondary to ureteral calculi. Int Urol Nephrol 2012; 44:71–9.
17. Tchey DU, Ha YS, Kim WT, Yun SJ, Lee SC, Kim WJ. Expectant Management of Ureter Stones: Outcome and Clinical Factors of Spontaneous Passage in a Single Institution's Experience. Korean J Urol. 2011; 52(12):847–51.
18. Zorba OU, Ogullar S, Yazar S, Akca G. CT-based determination of ureteral stone volume: A predictor of spontaneous passage. J Endourol 2016; 30(1):32–6.
19. Gücük A, Uyetürk U. Usefulness of Hounsfield unit and density in the assessment and treatment of urinary stones. World J Nephrol 2014; 3(4):282–6.
20. Hada, Ajayraj Y, Sher S, Tomar, Vinay P, Shivam A, et al. Assessment of factors affecting the spontaneous passage of lower ureteric calculus on the basis of lower ureteric calculus diameter, density, and plasma C- reactive protein level. Urol Ann 2018; 10:302.
21. Ongün Ş, Dursun M. The Effect of Distal Ureteral Stone Size Measurements on Spontaneous Passage. J Urol Surg 2019; 6:139–43.
22. Bourdoumis A, Papatsoris AG, Chrisofos M, Deliveliotis C. Lower Pole Stone Management. Med Surg Urol 2012; S4:004.