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Evaluation of renal function with renography in patients with renal colic

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Abstract: **Objective:** Urolithiasis is responsible for the majority of urological emergencies. Although computed tomography (CT) scan can identify urinary obstruction caused by stones, there is a growing concern about exposure to radiation made by this method. Renal scintigraphy can provide valuable insights regarding the functional status of kidneys and can significantly reduce exposure to radiation. The goal of present study was to assess renal function through renal scintigraphy in patients with acute renal colic and it explores the association between renal scintigraphy performance and ultrasound in terms of detecting hydronephrosis.

Methods: For this study, 20 patients with acute renal colic were chosen. Each patient underwent renal ultrasonography and subsequently received renal scintigraphy with Technetium-99m diethylenetriaminepentaacetic acid (Tc-99m DTPA). Cohen's Kappa coefficient and Cramer's V correlation were employed to demonstrate the extent of agreement between ultrasound and renal scintigraphy.

Results: 12 (60%) patients were male. Glomerular filtration rate (GFR) values were correlated with Cockcroft-Gault equation and the Gates method (P=0.002, r=0.642). There was a good agreement and a statistically significant relationship between ultrasound and renal scintigraphy in terms of detecting obstructive uropathy in both kidneys.

Conclusion: To conclude, GFR values were correlated between Cockcroft-Gault equation and the Gates method in patients with acute renal colic. There was a good agreement and statistically significant relationship between ultrasound and obstructive renography results in both kidneys. However, we found no association between perfusion phase of renal scintigraphy and ultrasonography in terms of hydronephrosis detection.

Keywords: Acute Renal Colic; Computed Tomography; Hydronephrosis; Renal Scintigraphy; Ultrasound

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1. Introduction

Symptomatic kidney stones account for the vast majority of urological disorders reported in the emergency department (ED) (1-3). Urinary tract obstruction (UTO) might be an unpleasant consequence of trapped stones, which can deteriorate renal function when left untreated (4). Stone-mediated UTO could be detected through non-contrast computed tomography (CT) which has a high sensitivity and specificity (5). It is worth noting that a recent cohort study with more than 12 million youth aged less than 19 years indicated the link between exposure to diagnostic low-dose radiation and the development of malignant tumors. More specifically, individuals who underwent a CT scan had an overall higher malignancy incidence, compared with non-exposed subjects (incidence rate ratio was 1.54; P<0.001) (6). On the other hand, ultrasonography (US) is readily available and virtually inexpensive and is used for diagnosing the UTO. It also does not contain ionizing radiation (7). Unfortunately, when it comes to the detection of hydronephrosis, ultrasonography has several limitations. A negative ultrasound cannot preclude the possibility of hydronephrosis in the presence of high clinical suspicion (8). Besides, ultrasound might result in false-positive diagnosis of mild hydronephrosis (9). In addition, radionuclide renography, also termed renal scintigraphy, is a dynamic diagnostic modality based upon gamma-ray emissions and it offers valuable information about physiological, anatomical, and pathological features of kidneys (10). Additionally, it can also distinguish obstructive hydronephrosis from non-obstructive and estimate the perfu-

sion status. Of note, exposure to radiation caused by the radioisotope renography is approximately one-tenth of an abdominal CT scan-mediated radiation (11). The present investigation evaluates renal function through renal scintigraphy in patients with acute renal colic and explores the association between renal scintigraphy performance and ultrasound in terms of detecting urinary obstruction.

2. Methods

2.1. Study design and setting

We prospectively recruited adult patients with acute flank pain, who were referred to the Imam Reza Medical Research and Training Hospital between January and June 2020. We sought to evaluate the ability of renal scintigraphy and ultrasound in determining the severity of hydronephrosis. The study carefully follows the principles of the declaration of Helsinki. Moreover, the research design was also approved by the Ethics Committee at Tabriz University of Medical Sciences (No. IR.TBZMED.REC.1398.1034). After providing information regarding all aspects of the trial, we requested all patients to sign the informed consent.

2.2. Study population

Twenty consecutive adult patients (≥18 years) with a complaint of acute flank pain and urinary symptoms like as frequency, dysuria, or hematuria, who admitted to the ED in the morning shift, were requested to attend the study. The participation of all patients was voluntary.

The study did not include patients who were not willing to participate or unable to sign an informed consent, those aged less than 18 years, pregnant women, and those who needed urgent urological evaluation, including acute kidney injury, sepsis, and anuria.

2.3. Study protocols

Initially, each patient underwent a general physical examination by a senior ED resident. We provided a checklist to record baseline characteristics (age, gender, body weight) and creatinine levels. The creatinine levels were assessed by Mindary autoanalyzer BS 800 (China) according to the kit's protocols. Simultaneously, to relieve the flank pain in the patients, they received symptomatic treatment with morphine sulfate 0.1mg/kg and hydration with normal saline. We did not use nonsteroidal anti-inflammatory drugs due to adversely influencing renal scintigraphy results. After controlling pain and associated symptoms, renal ultrasonography was carried out by the same attending radiologist for each patient. Afterwards, the senior ED resident reassessed the patient's hydration status, and they were requested to drink at least two glasses of water. Then, the patient was transferred to the unit of nuclear medicine in the same hospital within 3 hours in maximum. Before initiating the imaging protocol, the patient was asked to urinate to have an empty bladder.

Radioisotope renal scintigraphy was captured in the posterior view, and the patient was in the supine position. The radiotracer bolus, that is, 10 millicuries (mCi)of Technetium-99m diethylenetriaminepentaacetic acid (Tc-99m DTPA), was injected intravenously. The imaging acquisition was dynamically undertaken for 30 minutes and started immediately after the radiotracer injection. To assess the severity of obstructive uropathy, 0.3 mg/kg of furosemide was administered 10 minutes after the injection of Tc-99m DTPA. In the end, global and split glomerular filtration rate (GFR) were determined through the Gates method using patient's weight and height and also activity counts of right & left kidneys and backgrounds. We employed the Siemens E.CAM dual-head gamma camera with a low-energy high-resolution (LEHR) collimator to obtain a radioisotope renogram. The results of renal scintigraphy were interpreted by a nuclear medicine specialist, blinded to the results of the ultrasound. An example of a renal scan with obstructive uropathy with the corresponding renogram and angiogram is provided in figures 1 and 2, respectively.

2.4. Statistical analysis

The statistical analysis was performed in SPSS (Ver. 22). The Kolmogorov-Smirnov test was employed to assess normal distribution of the data. We used the chi-squared test and Fisher's exact test for evaluating the relationship between categorical variables.

Cohen's Kappa coefficient and Cramer's V correlation were utilized to show the extent of agreement between ultrasound and renal scintigraphy results. The significance threshold was the conventional value of 0.05 throughout the study. The association of continuous variables was assessed via Spearman's correlation.

3. Results

3.1. Baseline characteristics of participants

We recruited 20 patients with acute renal colic from the ED. Of them, 12 (60%) were male. The average age, weight, and creatinine of the subjects were 42.65±16.96 years, 70.85±13.31 kilograms, 1.22±0.35 mg/dL, respectively. The GFR based upon Cockcroft-Gault equation was: [median=80.47; interquartile range (IQR): 34.71-121.11]. However, according to the findings from renal scintigraphy, the GFR was: [median=102.75; IQR:28-118]. As can be seen in figure 3, there was a statistically significant correlation between GFR levels calculated by the two methods (P=0.002, r=0.642).

3.2. Ultrasound versus renal scintigraphy in detecting urinary tract obstruction

Table 1 illustrates the results of ultrasound and renal scintigraphy methods in diagnosing urinary obstruction, distinctly for each kidney.

As can be seen, there is a good agreement and statistically significant relationship between ultrasound and renal scintigraphy results in both kidneys. As shown in table 2, no as-

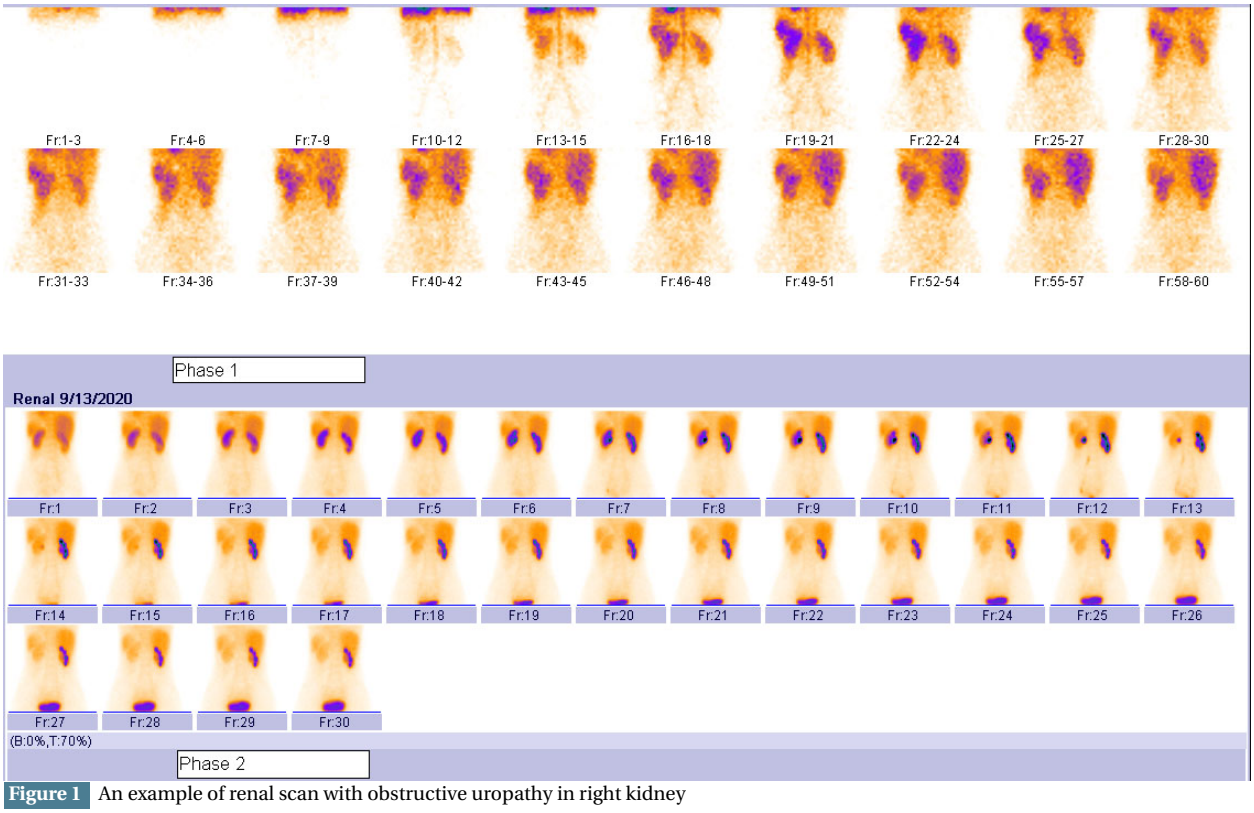

Figure 1 An example of renal scan with obstructive uropathy in right kidney

Table 1 Comparing the results of ultrasound and renography in terms of hydronephrosis detection

	Ultrasound results	Obstructive uropathy		P-value	Cohen's Kappa coefficient
		Negative	positive		
Right kidney	Negative	8 (80.0)	2 (20.0)	0.005	0.7
	Positive	1 (10.0)	9 (90.0)		
Left kidney	Negative	10 (76.9)	3 (23.1)	0.003	0.7
	Positive	0 (0.0)	7 (100)		

Table 2 Comparing the results of perfusion phase with ultrasound with regard to hydronephrosis detection

	Ultrasound results	Perfusion phase		P-value	Cohen's Kappa coefficient
		Negative	positive		
Right kidney	Negative	5 (50.0)	5 (50.0)	0.650	0.20
	Positive	3 (30.0)	7 (70.0)		
Left kidney	Negative	11 (84.6)	2 (15.4)	0.290	0.29
	Positive	4 (57.1)	3 (42.9)		

Table 3 Comparing the hydronephrosis severity between ultrasound and renography

	Ultrasound results	Obstructive uropathy			P-value	Cramer's V correlation
		Normal	Clear	Partial		
Right Kidney	Mild	2 (66.7)	0 (0.0)	1 (33.3)	0.001	0.662
	Moderate	0 (0.0)	4 (100.0)	0 (0.0)		
	Severe	0 (0.0)	3 (100.0)	0 (0.0)		
	Normal	8 (80.0)	1 (10.0)	1 (10.0)		
Left kidney	Mild	2 (100.0)	0 (0.0)	0 (0.0)	0.126	0.406
	Moderate	1 (20.0)	2 (40.0)	2 (40.0)		
	Normal	10 (76.9)	1 (7.7)	2 (15.4)		

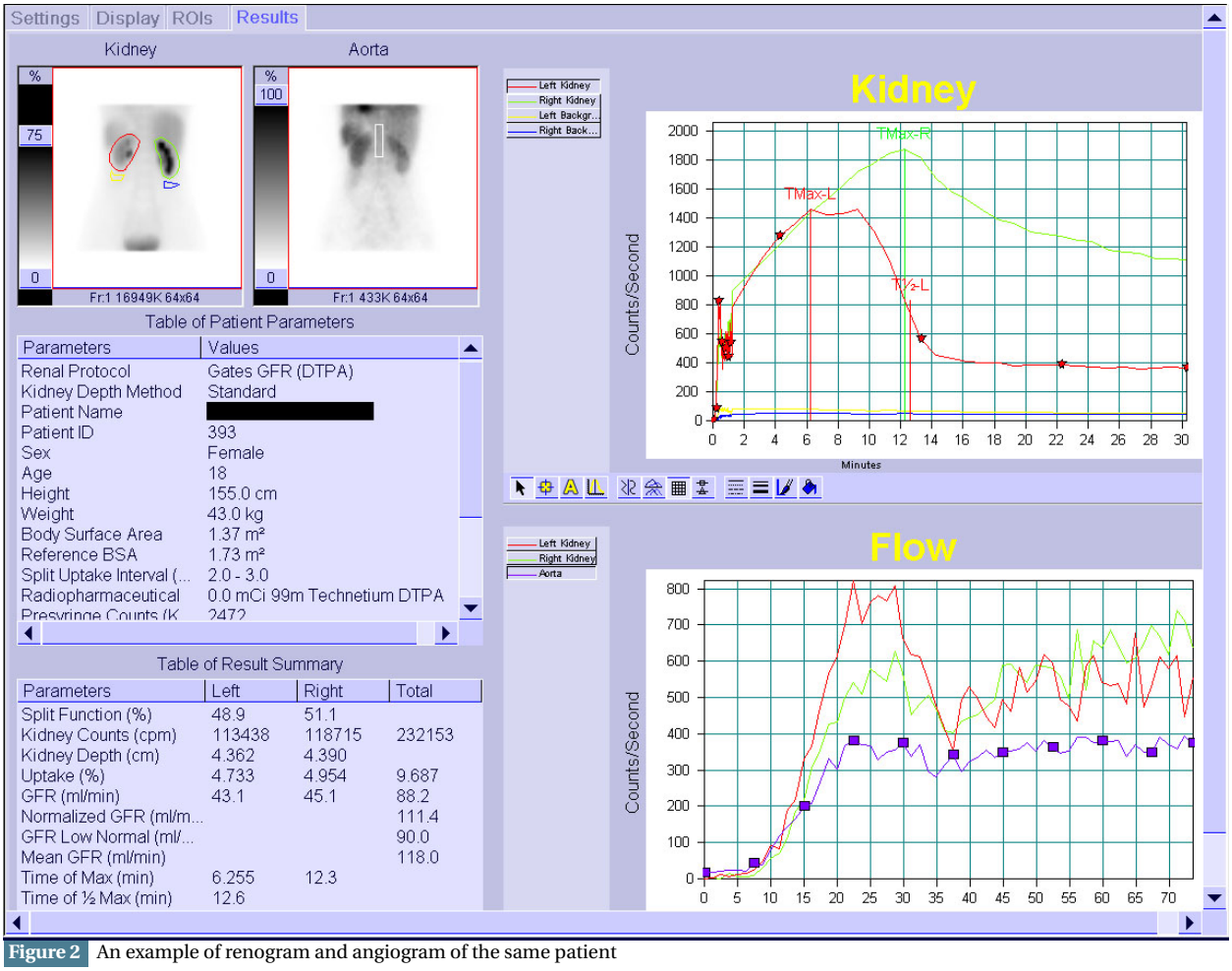

Figure 2 An example of renogram and angiogram of the same patient

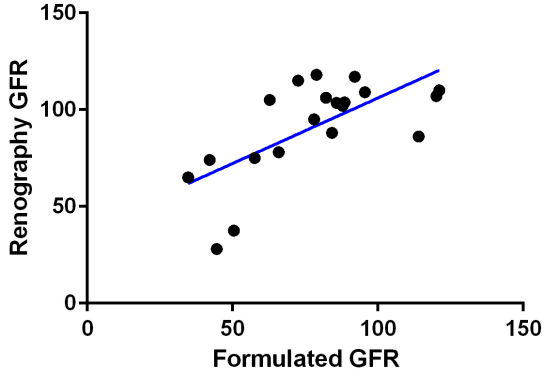

Figure 3 GFR levels calculated by the two methods

sociation was observed between the findings of the perfusion phase of renal scintigraphy and ultrasonography. In six cases, despite hydronephrosis in sonography, no perfusion scintigraphy abnormalities were observed. Besides, in other six cases, despite perfusion abnormality, ultrasonography showed no hydronephrosis. Finally, as table 3 tabulates, on the right side, there is a significant association between the classification of obstruction severity in scintigraphy and ultrasonography (Cramer's V=0.662). However, no association was found between these two factors when it comes to the left side.

4. Discussion

The findings suggested that GFR values were correlated between Cockcroft-Gault equation and the Gates method (P=0.002, r=0.642) in patients with acute renal colic. We found a significant agreement between ultrasound and renal scintigraphy results as far as urinary obstruction detection in each kidney was concerned (K=0.7). In the current study, the results of urinary obstruction by renal scintigraphy and ultrasonography were not the same in six patients. In four patients, in spite of no observation of obstruction in ultrasonography, obstructive uropathy was found in renal scintigraphy. These findings can be justified by taking into account lower sensitivity and specificity of ultrasonography in detecting hydronephrosis. In the study by Sibley et al., the operator's capability in performing ultrasonography, body mass index, time interval between performing ultrasonography and CT scan had no significant effect on increasing sensitivity

and specificity of ultrasonography (12). In two cases, despite mild hydronephrosis observed via ultrasonography, no obstructive uropathy was reportedly by scintigraphy. This is likely due to mild obstruction and its removal following hydration in the time interval between scintigraphy and ultrasonography (13).

In the present study, no relationship was observed between the findings of ultrasonography and the perfusion phase of scintigraphy. In four cases, the reason behind the abnormal perfusion phase might be related to obstructive uropathy, which was not detected in ultrasonography. Decreased perfusion without noticeable obstructive uropathy in two other patients can be ascribed to underlying diseases such as vascular abnormalities (14). On the other hand, preserving renal perfusion in the setting of mild obstruction identified through scintigraphy might stem from the negligible impact of mild obstruction on perfusion and a concomitant compensatory increase in renal function (15). Several other studies also reported the lack of association between the findings of the perfusion phase in renal scintigraphy and obstructive uropathy. In the study of Want et al. on rabbits with hydronephrosis, no association was observed in the findings of perfusion phase and obstructive uropathy (16). However, in another study on rabbits, renal blood flow was in direct proportion to the degree of hydronephrosis (17). It is worth mentioning that a non-contrast CT scan can estimate stone size and provides anatomical information in patients with acute urolithiasis. It should be noted that knowing the characteristics of stone can positively contribute to the proper management of urolithiasis (18). Also, CT scan can be employed in patients with renal failure as renal scintigraphy does not yield substantial information (19). However, as alluded to earlier, there is a growing concern about exposure to radiation by this modality (6). In addition, CT scan cannot offer quantitative data about the functional status of kidneys (20). Research has shown that renal scintigraphy is a modality which has been infrequently used in patients with nephrolithiasis (9). The scintigraphy results of a study on 80 patients with acute renal colic and positive helical CT scan showed that CT scan had a 56% positive predictive value for identifying obstruction. This conclusion was made that radioisotope scintigraphy should be employed to stratify patients in terms of the requirement for urgent intervention or elective approaches (21). Another study which examined the accuracy of ultrasound in comparison with renal scintigraphy found that ultrasound has a 43% positive predictive value for diagnosing obstruction in pregnant women (22). Nonetheless, our study has several limitations. It was conducted on a limited number of patients. Although comparing renal scintigraphy with a CT scan can offer invaluable insights, significant radiation exposure does not justify a comparative evaluation.

5. Limitations

This was a pilot study with a small sample size and conducted in one center. This can limit the generalizability of results. Further studies with larger sample size and multicenter studies are needed to improve the generalizability of results.

6. Conclusion

To conclude, GFR values were correlated between Cockcroft-Gault equation and the Gates method in patients with acute renal colic. There was a good agreement and statistically significant relationship between ultrasound and obstructive uropathy in renal scintigraphy results in both kidneys. However, we found no association between perfusion phase of renal scintigraphy and ultrasonography.

7. Declarations

7.1. Acknowledgement

This research was extracted from the thesis for a M.D thesis by Faezeh Tarighat entitled, “Evaluation of renal function with renography in patients with renal colic and its relation with hydronephrosis”. It is registered at Tabriz University of Medical Sciences (No: 63374) in 23-12-2019. We would like to appreciate of the cooperation of Clinical Research Development Unit, Imam Reza General Hospital, Tabriz, Iran in conducting of this research. The authors are grateful to all the health staff who participated in the study.

7.2. Authors' contribution

Study concept and design: HS, EG, MB, AG and FT; Drafting of the manuscript: SPP, KH and RME. All authors have read and approved the manuscript. All authors reviewed the manuscript.

7.3. Conflict of interest

The authors declare no conflict of interest.

7.4. Funding

This study was supported by Road Traffic Injury Research Center, Tabriz University of Medical Sciences, Tabriz, Iran.

7.5. Consent for publication

Not applicable.

7.6. Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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