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RESEARCH ARTICLE

Value of Magnetic Resonance Urography Versus Computerized Tomography Urography (CTU) in Evaluation of Obstructive Uropathy: An Observational Study

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ARTICLE HISTORY

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Abstract: ***Background***: Obstructive uropathy is a common public health issue that requires imaging research for providing necessary information. The data is important for determining treatment options, and may influence selective management choices.

Objective: The aim of the study is to determine whether magnetic resonance urography or computerized tomography urography is the best imaging modality among patients with suspected obstructive uropathy.

Methods: Seventy patients; referred from the emergency department for the evaluation of renal colic or hematuria that highly suggested urinary tract abnormalities, were prospectively enrolled. Thirty five women and 35 men were categorized with a mean age of 43.52 years and the mean body weight of 61.31 kg. All participants underwent abdominal ultrasonography and clinical examination to detect the causes of urinary obstruction. Pregnant women were excluded from the study. Both magnetic resonance urography and computerized tomography urography were performed within 30 days of each analysis.

Results: Only 54.3% of the participants had urinary stones. Mean size of the renal stone was 11 mm; while mean size of the ureteral stone was 3.8 mm. The approach of magnetic resonance is not only limited to diagnosis, but is also effectively involved in the real time investigations. MRU has more reliability in terms of the diagnosis and anatomic presentation of the kidneys along with the vasculature. All cases of urinary stones were detected by computed tomography (100%); whereas, 78.9% cases were detected by magnetic resonance urography.

Conclusion: Computerized tomography urography is more sensitive in detecting kidney stones; whereas, magnetic resonance urography is better in detecting pathology behind the development of kidney stones.

Keywords: Magnetic resonance urography, computerized tomography urography, obstructive uropathy, renal stones, urinary stones, urinary obstruction, kidneys.

1. INTRODUCTION

Obstructive uropathy refers to any blockage in the urine drainage system. The obstruction can occur at any position of the urinary tract that may involve the pathway from the kidney, ureter, till the bladder [1]. As a result of this obstruction, urine can collect back into the kidneys. The collection may lead to damage to the renal calyces, renal pelvis, and ureter. The inability to pass out the urine from the body exerts pressure on the system that can specifically occur at any site. The pressure generated within the urine storing kidneys causes distention inside the structures. The dilation caused within the renal calyces and pelvis is known as hydronephrosis [2, 3]. Obstructive uropathy has a potential of being both; either a chronic condition, which affects the individual for a long term or an acute state that tends to have a sudden onset. Moreover, it is not necessary that the obstruction occurs in both the kidneys simultaneously. It may also affect one kidney at a time. A condition that distresses one kidney is known as the unilateral obstruction while a condition occurring in both the kidneys is termed as the bilateral obstruction [3].

Symptoms of the obstructive uropathy has been known to be frequently presented with nausea, vomiting and excessive sweating or diaphoresis as well as the pain in abdomen and groin [4]. Clinicians have identified several underlying causes of obstructive uropathy amongst which the most prevalent ones are noted to be the kidney stones, ureter stones or urinary tract stones [5]. Apart from the stone for-

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mation, the causes of obstruction may also include certain health conditions that can be pregnancy, prostate cancer, retroperitoneal fibrosis [6], spinal cord injury [7], ureteral stricture, and congenital anomalies; *e.g.* ureteropelvic junction obstruction [8]. The efficacy of urine transport primarily depends on the formation of connections between the structures and physiology of the organs, particularly the kidneys and ureters. In the condition of obstruction in kidneys, the development of smooth muscle cells, lining the pelvis and ureter, falls into a greater risk of damage. Damage to the renal pelvis and impairment in the smooth muscle differentiation is the prime source of physiological obstruction in the urinary tract.

A study has identified the significance of smooth muscle cell lining in the development of kidneys, particularly in the late phase of human gestation. The situation has indicated that the head of the baby inside the womb rests at the pelvis of the mother. In this particular position, urinary movement occurs against the force of gravity. In any case, if the mechanism of peristaltic waves fails to arise and conduct, it can lead to the physiological obstruction in the kidney [9, 10]. Magnetic Resonance Urography (MRU) is a high specificity sensitive modality for diagnosing non-calculus obstructive uropathy, caused by lesions as pelvi-ureteric junction [PUJ] obstruction. MRI can provide functional and anatomical data about possible obstruction in kidney without using nephrotoxic contrast media or causing ionizing radiation [11]. It has been evaluated that MRU has delivered highest accuracy for the detection of obstruction and hydroureteronephrosis [12]. It has a lower sensitivity in detection of urinary calculi as compared to other modalities. MRU is a better modality for the evaluation of malignant as well as benign causes of obstruction due to its multi planar capability and superior soft tissue contrast [12]. Computed Tomography Urography (CTU) is a powerful assessment machine for the urinary tract [13, 14]. CTU is useful for the diagnosis of renal stones and detection of its composition [15]. The intravenous urography has become disrepute after the development of competitive imaging modalities and apprehension about the adverse effects of radiation and contrast media. However, intravenous urography is not efficient to detect kidney stones that might result in urinary tract obstruction. Therefore, MRU technique is needed to determine the causes and level of obstruction.

The Non-Contrast-Enhanced Computed Tomography (NCCT) is the best imaging modality for the detection and follow-up of urolithiasis [16]. Radiation dose is currently one of the major disadvantages of CT [17]. Ferrandino, *et al.* have noted that about 20% of the patients received significant radiation doses during short-term follow-up of an acute stone [18]. NCCT can diagnose other causes of urolithiasis as malignancies [19]. High radiation exposure, associated with CT, makes many investigators to use MRI as an alternative; even CT has superior accuracy in diagnosis of urinary tract obstruction [20, 21]. On the basis of such literature, the study has aimed to determine whether magnetic resonance urography (MRU) or computerized tomography urography (CTU) is more efficient to detect the cause of obstructive uropathy. CTU and MRU techniques are non-invasive; whereas, use of CT and MRI contrast agents involves the injection of agent intravenously to complete the scan. These agents help the radiologist to observe minute details on the scans that are not visible otherwise. The adverse effects of these contrast agents include kidney damage and skin disorder, known as nephrogenic systemic fibrosis (NSF). The risk of developing these conditions increase among the patients with poor kidney function.

2. NOVELTY OF THE STUDY

MRU helps in the identification and evaluation of obstruction by allowing a global, non-invasive visualization of the whole urinary tract without administrating contrast agents and ionizing radiation. Previous studies have used CTU for diagnosis and evaluation of obstruction without any magnetic resonance urography. Whereas, the present study has demonstrated the potential and applicability of magnetic resonance urography in the diagnosis of obstructive uropathy.

3. MATERIALS AND METHODS

Seventy subjects, admitted for assessment of renal colic and abdominal pain, were recruited from the emergency department. These patients were highly suspected for urinary tract disorders. The participants included 35 women and 35 men with a mean age of 43.52 years (ranged from 28 to 61 years), and the mean body weight of 61.31 kg (ranged from 46 to 78 kg). Consent form was signed by all the participants. The participants were subjected to abdominal ultrasonography and clinical examination. The sample size was determined on the basis of patients who visited the clinical setting with complain of obstruction; however, pregnant women were excluded from the study. Magnetic resonance urography and computerized tomography urography were performed within 30 days. MRI was systematically performed, and it has influenced the ability to detect the acute causes of obstruction. In all cases, MRI was performed after CTU in the duration of three hours. The number of stones, presence of hydronephrosis and hydroureter, congenital pelvi-ureteric junction obstruction, presence of neoplastic mass, cysts and ureteric wall thickening were evaluated for both the techniques. The stone size (in mm) was determined in the largest single dimension.

Ultrasonography of the kidneys, ureter and bladder region was done with a 3.5/ 5 MHz curved array probe of LOGIC 200 pro series - GE system. Patients were examined with full bladder and if there was a suspicion of hydronephrosis, they were re-examined after the evacuation of the bladder. This was done to exclude the possibility of pseudohydronephrosis. Computerized Tomography Urography (CTU) was undertaken using a multi-detector helical scanner (Aquilion 64, ToshibaTM) starting at the level of kidneys with patient holding of breath (beam collimation 5mm×1.25 mm; pitch 6; scanning time about 20s). Magnetic Resonance Urography (MRU) was performed using 1 Tesla Magnetom Harmony Siemens Medical System. In all cases, MRI was performed with contrast agents. Heavily T-2 weighted pulse sequences were used to demonstrate the water content of urinary tract. RARE imaging or Turbo spin-echo sequences were used as options for obtaining images in short data acquisition time. This helped in improving the contrast between urinary tract and retroperitoneum. Omniscan (Gadodiamide Gd DTPA-BSA) was given in a dose of 0.1mmol per kilogram by hand injector for contrast enhanced studies. It helped to demonstrate the extent and nature of neoplastic and inflammatory pathology. Post contrast T1 weighted sequences were repeated in coronal and transverse planes. Post processing was performed using the Maximal Intensity Projection (MIP) algorithm. Signal void area was surrounded by hyper intense urine within the urinary tract that indicated the presence of a calculus. The data has been analyzed for the descriptive approach in order to compare the recorded incidence. This study was approved by the Scientific Research Ethical Committee, Faculty of Applied Sciences, King Abdulaziz University.

4. RESULTS

70 patients were recruited from the emergency department, who were admitted for the assessment of renal concerns and abdominal pain. The participants were comprised of both male and female individual; out of which, 35 were women and 35 were men with a mean age of 43.52 years (range 28-61 years), and mean body weight of 61.31 kg (range 46-78 kg).

38 out of 70 patients were found to have urinary stone (54.3%). The mean size of the renal stone was 11 mm (range, 5-18 mm) and the mean size of the ureteral stone was 3.8 mm (range, 3-6 mm). The size of stones smaller than 3.8mm were not detected through MRU. Among the remaining patients, 3 patient had pelvi-ureteric junction (PUJ) obstruction (4.3%), four patients had neoplastic mass (5.7%), two patients had ureteric wall thickening (2.8%) and three patients had cysts (4.3%) (Table **1**). The remaining 20 patients, who had no urinary tract abnormalities identified through US; therefore, these patients were not included in the final study population. Final clinical diagnosis included three patients who had lumbar disc lesion related pain (4.3%), six patients had gastroenteritis (8.6%), eight patients had inflammatory pelvic disease (10.7%), and only three patients had prostatitis (4.3%).

Regarding the detection of urinary obstruction by CTU, all the cases of urinary stones were detected by CTU (100%); 2 out of 3 patients were suffering with congenital PUJ obstruction (66.7%), 3 out of 4 patients with neoplastic mass (75%), 1 out of 2 patients with Ureteric wall thickening (50%), and 2 out of 3 patients with cysts (66.7%). While, only 30 out of 38 patients (78.9 %) with urinary stones were detected by MRU. Moreover, all patients with congenital PUJ obstruction, neoplastic mass, ureteric wall thickening and cysts (100%) were detected by MRU (Table **2**).

5. DISCUSSION

Magnetic Resonance Urography (MRU) and Computed Tomographic Urography (CTU) are increasingly valuable tools for the assessment of urinary tract disorders. Each imaging technique has its own advantages and disadvantages although both of them provide imaging with excellent definition for normal and pathological conditions [22]. The main findings indicated that about 54.3% of the participants had urinary stone; the mean size of renal stone was 11 mm (range, 5-18 mm) and the mean size of the ureteral stone was 3.8 mm (range, 3-6 mm). All cases of urinary stones were detected by CTU (100%); whereas, only 78.9% patients with urinary stones were detected by MRU. 66.7%, 75%, 50%, and 66.7% of patients with congenital PUJ obstruction, neoplastic mass, ureteric wall thickening, and cysts respectively were detected by CTU. On the other hand, 100% of patients with congenital PUJ obstruction, neoplastic mass, ureteric wall thickening and cysts respectively were detected by MRU. The results were completely aligned with past literature and show that CTU is more sensitive in detecting stones; however, MRU does better in detecting pathology behind the development of kidney stones.

Table 1. Number and percentage of the detected causes of urinary tract obstruction and urolithiasis.

Findings		**N (%)**
Urinary Stone	Number of patients who had stones	38 (54.3%)
	Number of detected stones	61 -
	Stone in kidney	30 (42.8%)
	Stone in PUJ	4 (5.7%)
	Stone in ureter	25 (35.7%)
	Stone in bladder	2 (2.8%)
Congenital pelvi-ureteric junction [PUJ] obstruction		3 (4.3%)
Presence of neoplastic mass		4 (5.7%)
Ureteric wall thickening		2 (2.8%)
Cysts		3 (4.3%)
Consequences of Obstructive Uropathy		
Hydronephrosis		19 (27.1%)
Hydroureter		13 (18.6%)

Table 2. Detection of cause of urinary obstruction by various imaging modalities.

Obstruction Cause	Number of Cases	CTU N (%)	MRU N (%)
Urinary stone	38	38 (100%)	30(78.9%)
PUJ obstruction (congenital)	3	2(66.7%)	3(100%)
Presence of neoplastic mass	4	3(75%)	4(100%)
Ureteric wall thickening	2	1(50%)	2(100%)
Cysts	3	2(66.7%)	3(100%)

The study has used this approach because 3T images are generally at least equal to 1T images for the diagnosis of kidney stones. 1T images are considered adequate as they are sufficient in diagnosing lower kidney stones. MRU is accurate in assessing renal functions, and could be used as a single modality for diagnosing obstruction in cases, where patients would not be compromised due to renal function contraindications [23]. Moreover, Jung *et al*. stated that MRU reached the correct diagnosis in 88.9% of patients with ureteric stone, while conventional intravenous urography reached the correct diagnosis among 68.1% of the patients [24].

Computed tomography has become a preferable modality in health examination due to its imaging resolution and quick examination time. It has been known as a potential mode for diagnosing the urinary tract anomalies. CTU is highly accurate for the conditions; like urolithiasis. Lin *et al*. recruited 102 patients, who underwent CTU, where only 40 patients were proved to have urolithiasis and CTU reached the right diagnosis of 97.5% patients with urolithiasis [25]. Also, Ather *et al*. compared the sensitivity and specificity of US and NCCT among patients with renal failure and proved that they were 81% and 100%, respectively, for renal stones, and 93% and 100% for hydronephrosis [26]. Xie *et al*. conducted study to compare between Intravenous Urography (IVU) and Computed Tomography Urography (CTU) in Diagnosing Ureteropelvic Junction Obstruction (UJO) and proved that the diagnostic accuracy was 85.2% in CTU and 49.2% in IVU. Moreover, the study concluded that CTU has higher diagnostic efficacy as compared with IVU [27]. Finally, Khan *et al*. proved that CTU as compared with IVU had a higher detection rate for ureterolithiasis, especially for stones in the distal ureter [28]. Moreover, Shokier *et al*. concluded that MRU is more sensitive and specific for non-calculous urinary tract obstruction as compared to CTU [29].

MRU is considered as an efficient method for studying the renal artery stenosis. It should be noted that the condition of renal artery stenosis tends to be asymptomatic, while the prevalence remains high. Therefore, a number of modalities have been employed to deliver imaging of the anatomy of system to distinguish the physiological significance of the stenosis. The treatment to the disorder is provided on the basis of monitoring due to its asymptomatic nature. Whereas, the approach of revascularization in the kidneys is also developed on the basis of imaging through MRU technique [30, 31]. A study revealed that MRU is the most opportunistic noninvasive modality for diagnosing and monitoring kidney stones [32]. It has emerged as a preferable and efficient approach for the evaluation of renal functions. The first pass signal for cortical enhancement with the use of MRI has markedly decreased the necrosis in the allografts. It has also helped in identifying the reduced flow of blood in cortex and medulla of the kidneys. The MRU has helped to determine the incidence of rejection that is increased higher in vasculatures [33].

The use of CTU and MRU has increased the ability to image the urinary tract in such a way that it surpasses the prior investigations. A study conducted by Silverman *et al*. [34] showed that CTU provides detailed anatomic evaluation of major portions of the urinary tract; whereas, MRU is advantageous as it does not involve any ionizing radiation. Therefore, MRU tends to provide more functional information as compared to CTU. Another study revealed that as compared to CTU, MRU is efficient in differentiating between the lower and upper poles of the kidneys [35]. As compared to CTU, MRU is likely to become the primary investigation technique in the selected patients because it does not entail exposure to radiation [36].

The images obtained from the screening provides complete and detailed visualization of the tracts in the urinary system. The investigative tool of MRU in urological domains has not only assisted in avoiding great damage to the human lives, but has also contributed to omit the intravenous and incisional approach from the field [30-33]. The tumors with different biological features and behaviors can be efficiently observed and determined by the MRI urography. MRU is known to have better contrasts for soft tissues, avoids the ionizing radiations, and usage of iodinated contrast media that makes it a more effective modality as compared to CTU. Moreover, the technique has further alternatives that can be approached via detailed evaluation of renal vasculature, micro structures, and oxygenation of the system. Acute renal failure is a rapidly progressing and reversibly declining glomerular filtration rate that can critically affect the individual within days or weeks. The causes of acute renal failure can be renal ischemia or renal parenchymal disorders that need to be diagnosed on time for the assessment, management, and treatment. Therefore, MRU has provided major assistance in developing clinical strategies for dealing with this condition [33].

CONCLUSION

The study has concluded that CTU is more sensitive in detecting kidney stones; whereas, MRU is better in detecting pathology behind the development of kidney stones. As compared to CTU, MRU has provided better contract resolution. This comparison has been conducted on the basis of the ability to detect changes between the normal and pathological tissues. Moreover, these techniques provide high resolution for anatomic imaging without the exposure to ionization or radiations. CTU is more sensitive in evaluating the condition of obstructive uropathy. The study has suggested that the MRU has more reliability in terms of the diagnosis and anatomic presentation of the kidneys along with the vasculature. It has been stated that the functional approach of MRU requires more technical input for the clinical assessment. These techniques have helped in further evaluation of the pathological conditions. MRU has provided numerous advantages in the clinical field with respect to the rising prevalence of renal diseases and growing rates of complications.

LIMITATIONS

Apart from the results obtained regarding the urinary stones, other causes including PUJ obstruction and neopalsams are very limited to state a certain sensitivity. However, addition of few more patients would alter the present results. These values have not been accompanied by 95%-confidence intervals, which would be unacceptably high in these cases. Another limitation of the study is the use of 1 T MRU scanner.

RECOMMENDATIONS

The study has recommended that CTU possess diagnostic confidence in detecting urothelial malignancy as compared to MRU. It is recommended for the patients who are at low risk for malignancy and for evaluation of the obstructed patients. CTU provides diagnostic confidence in recognition and exclusion of urothelial tumor due to the presence of lower number of indeterminate tract. Moreover, the study has recommended that CTU is not sensitive in depicting urinary tumor. On the other hand, MRU offers visualization of excretory tract in an obstructed and impaired kidney.

LIST OF ABBREVIATIONS

MRU	=	Magnetic Resonance Urography
CTU	=	Computerized Tomography Urography

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Scientific Research Ethical Committee, Faculty of Applied Medical Sciences, King Abdulaziz University.

HUMAN AND ANIMAL RIGHTS

This research does not have experiments involving animal or human subject.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

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