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DIAGNOSTIC VALUE OF SINGLE SHOT FAST SPIN ECHO (SS-FSE) SEQUENCE AND THREE DIMENSIONAL FAST SPIN ECHO (3D-FSE) TECHNIQUE MAGNETIC RESONANCE UROGRAPHY IN EVALUATION OF OBSTRUCTIVE UROPATHY

Radio-Diagnosis

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ABSTRACT

Introduction: Magnetic Resonance Urography (MRU) is a relatively new and developing technique for the evaluation of obstructive uropathy. It offers unique advantages in terms of safety, particularly in patients where exposure to radiation and contrast are of concern. **Aims and objectives:** The current study aims to evaluate the diagnostic value of SS-FSE and 3D-FSE techniques of MRU in identifying the varied etiology of obstructive uropathy (OU) and grading the level of obstruction. **Materials and methods:** A prospective cross-sectional study was conducted using demographic and clinical data of obstructive uropathy (OU) patients (n=30) who underwent Magnetic Resonance Urography (MRU) evaluation using SS-FSE and 3D-FSE sequences after informed consent was obtained. Individual case details documented included age, gender, complaint, location of lesion/obstruction, laterality, hydronephrosis grade, blood urea and serum creatinine, urinary pH, calcium, and oxalates levels. Statistical analysis of the data thus documented in a Microsoft Excel sheet was performed using Version 25 SPSS. **Results:** The study showed calculus obstruction as the leading cause of uropathy in the study population (76.7%, n=23 out of 30 patients) with distal ureter being the most commonly obstructed (39%, n=9 out of 23 patients). Our analysis revealed the overall diagnostic accuracy of SS-FSE (n=22, 95.7%) and 3D FSE (n=23,100%) sequences when used in conjunction to be very similar to that of CT (n=23,100%) in evaluating etiology. **Conclusion:** The study concludes that both the MRU sequences of single-shot fast echo and three-dimensional fast spin echo sequence have significantly high diagnostic value in identifying etiology and grading obstructive uropathy (OU). Further advancements in Magnetic Resonance Urography (MRU) sequences can play a major role in developing a comprehensive protocol or even single step investigation for evaluation of Obstructive uropathy.

KEYWORDS

Magnetic Resonance Urography, Single-shot fast spin echo, 3D fast spin echo, Obstructive uropathy.

INTRODUCTION

Obstructive Uropathy (OU) encompasses a plethora of conditions affecting urinary excretion and can be broadly grouped into those affecting the functional aspect of renal filtration and excretion by the collecting system or those causing mechanical obstruction to the flow along any part of the urinary tract. These conditions invariably cause a buildup of pressure to involve one or both kidneys, depending on the location, resulting in unilateral or bilateral hydronephrosis. The grade of hydronephrosis depends on the degree of obstruction as well as the onset being acute or insidious.

Clinically, patients with OU may present acutely with symptoms such as urinary incontinence or severe radiating flank and lower abdominal pain, hematuria, severe strain upon commencing voiding of urine, fever, or may even be asymptomatic in chronic cases. Epidemi ologically, OU is diverse and may involve populations of all age, genders, and demographic locations.[1] Parasitic obstructions, adenopathy or fibrosis involving retroperitoneum, ureterocele, bladder endometriosis, urolithiasis, dysfunction of bladder (neuropathic), urate nephrolithiasis, fibroids and other pelvic masses and colonic endometriosis are additional causative factors of OU, even though some of these are less frequent.[2-7]

MRU techniques can be broadly clustered into either static or dynamic sequences. S-MRU techniques like SS-FSE having heavy T2WI as the core sequence utilize long T2-relaxation time of urine to depict the dilated ureters as a stationary column filled with bright urine. This aids in demonstrating any luminal obstruction such as calculus, blood clots, or even soft tissue neoplasms as dark defects within the distended column. Thus, a precise level of obstruction can be localized. However, for optimal imaging the tracts may be dilated by administering normal saline intravenously prior to imaging. Moreover, drinking water is discouraged to enhance contrast from adjacent bowel, and voiding just prior to starting the study further aids in patient comfort and compliance to the procedure. S-MRU however, has a drawback in its inability to assess functional excretion and this lacuna is filled with dynamic imaging sequences such as 3D GRE which is T1 based and requires contrast administration (Gadolinium-Gd). S-MRU is relatively safe and well tolerated in impaired kidney function patients while D-MRU can be used with caution only in mild cases of dysfunction and best avoided in moderate to severe renal parenchymal disease as they are prone to develop nephrogenic systemic fibrosis.

The imaging of MRU is expensive, time-consuming, and skill-intensive. It has also been observed to have various drawbacks, including reduced spatial resolution, an incapacity to examine calcifications effectively, and a vulnerability to a variety of artifacts.[8] The excellent contrast resolution, exceptional sensitivity for contrast media, and, most significantly, the safety of MRU is only a few of its many well-known benefits. There are no basic restrictions on using MRU[9] and it is frequently advised as a good substitute for Computerized Tomography Urography (CTU) whenever the latter is undesired or inappropriate.[10] MRU is already a well-researched imaging technique in the examination of the Upper Urinary Tract (UUT) in infants and children, but investigation for broader applicability in adults is scarce. MRU has earlier been demonstrated to be remarkably precise in the assessment of patients with acute clinical signs[11] and highly sensitive at recognizing the existence and level of a blockage.[12]

The (SS-FSE) sequence, being exceedingly T2WI, produces static hydrographic visualization of fluid throughout the urinary tract. Due to its inability to see completely non-dilated ureters, it is well acknowledged that single-shot fast spin-echo (SS-FSE) is only effective for evaluating dilated systems.[13] Therefore, the approach that is most frequently employed in everyday practice to assess the non-dilated collecting system is the 3-Dimensional (3-D) Fast Spin-Echo (FSE) technique. Rough information on renal function is also provided subsequently.[14]

MATERIAL AND METHODS

A prospective, cohort study was conducted on 30 study subjects who presented with clinical manifestations along with abnormal blood urea levels and subsequently, diagnosed radiologically to have obstructive

uropathy. Patient information, which could be collected prospectively was entered into a Microsoft Excel spreadsheet for further statistical analysis, which included variables like age, gender, clinical presentations, blood investigation such as serum markers, and blood urea levels, etiology of obstruction, and the extent of obstruction based on evaluating MRI sequence such as SS-FSE and 3-D spin (fast) echo technique identifications individually. The study involves the analysis of baseline demographics such as age and gender, besides clinical features, blood investigation variables, and single shot spin echo sequence and three-dimensional fast spin-echo technique outcome separately. All study participants received an explanation of the study's goals and the nature of the investigation. Only after receiving the informed consent of the patient and clearance from the Institutional Ethics Committee (IEC), the study was initiated.

Apart from patient preparation for routine MR investigations such as screening for metallic or magnetic objects, a few special measures were taken for imaging during the study to ensure maximum patient comfort and compliance with the procedure as well as improve imaging quality. To achieve optimal distension of the ureters, which is of paramount importance in SS-FSE, saline infusion was given intravenously. However, drinking water orally was discouraged as this would contribute to intra-bowel fluid which could reduce contrast resolution. Immediately prior to initiating the procedure, the patient was directed to void to ensure stress-free scanning.

In addition, study brochures were provided to the patients according to their language of preference and then, informed consent was acquired from the patient. The details of each case were recorded prospectively, including age, gender, chief complaints, location of lesions, laterality involved, hydronephrosis grades (extent of obstruction), blood investigation such as blood urea, and serum creatinine, urine analysis comprising pH, urine calcium, urine oxalates, besides the findings of MRU were collected prospectively and detailed in the Microsoft excel sheet for statistical analysis.

One individual supervisor or examiner after analysing the ultrasound and CT-urogram investigation findings, finalises the findings of etiology and the extent of obstruction which would be further validated by another experienced supervisor of more than 10 years. Hence, the CT correlated finalized results would be regarded as the comparator. The CT correlated comparator was evaluated with the findings of the single shot spin echo and three-dimensional fast spin echo sequence findings individually, and thereby, the diagnostic value of the sequence is validated in terms of sensitivity.

RESULTS AND ANALYSIS

The age average of the complete study was quantified to be 51.9 ± 17.2 years and their age ranged from 25 to 79 years. Among the patients, most of study included populations were in the age group of 61 to 70 years (30.1%, n=9) followed by equal distribution of percentages in 31 to 40 years and ≤ 30 years with 16.7% (n=5), each individually, once again with matched percentage of individuals in the age groups of 51 to 60 years with 13.3% (n=4) each separately, and finally with the age group of 41 to 50 years (n= 3,10%). (Table 1)

The majority of the patients were males (n=23, 76.7%) than females (n=7,23.3%). The result analysis signifies that males are predominantly affected irrespective of age, whereas the female gender was impacted at the age group of 41 to 50 years, and thereafter beyond 59 years.

The most significant clinical manifestation was in individuals who had more than two clinical features (n=14,46.7%) followed by patients with abdominal pain (n-9,30%), patients with mass per abdomen (n=4,13.3%), and hematuria (n=3,10%). The average age of the study included a population who had been diagnosed with renal calculi and ureteric calculi were determined to be 45.5 ±16.4 years (ranging from 25 to 70 years) and 48.5 ± 17.9 years ranging from 28 years to 75 years.

With reference to the corelative CT, the etiology of obstructive uropathy was established, with the most common cause being a calculus in 23 patients in total, out of which ureteric calculi were present in 15 study participants (65.2%), and renal calculi were present in 8 patients (34.8%). (Table 2) Among the total 30 enrolled study participants, 76.7% (n=23) had calculus disease and the remaining population had a combination of pathologies which accounted for 23.3% (n=7). The mixture of the population had an equivalent distribution of patients with ureterocoele and multiple cysts in 6.7% (n=2) each correspondingly, and with again matched distribution of patients with pelvic tumours, psoas collections, and pyelonephritis in 3.3% of the population (n=1) each respectively.

The average age of the patients who had renal and ureteric calculi was estimated to be 45.5±16.4 years and 48.5±17.9 years (p=0.70) and there was no difference in age between the patients with renal and ureteric calculi statistically.

The majority of the patients having renal calculi and ureteric calculi were predominantly male (87.5%, n=7 vs 73.3%, n=11) than females (12.5%, n=1 vs 26.7%, n=4).

The majority percentage of the population with renal calculi had at least more than two clinical features (50%) followed by haematuria (25%), and with an equal distribution of patients with mass per abdomen and abdominal pain in 12.5% of the population each individually at the time of presentation to our hospital.

The majority percentage of the population with calculus disease has a moderate level of obstruction (47.8%, n=11), followed by mild obstruction (n=10,43.5%) and severe (8.7%, n=2). (Table 3)

Out of 23 patients evaluated for the location of calculi among calculus disease patients, it was observed that a higher proportion of the population has calculi present in 9 patients (39%) in the lower ureter among the total study population followed by mid ureter in 6 patients (26%), upper ureter in nil patients (0%) and renal in 8 patients (35%).

A greater proportion of the population had a milder elevation in blood urea levels in 43.5% (n=10) followed by blood urea with normal limits in 30.4% (n=7), and high levels in 26.1% (n=6) of the population.

Out of 23 patients with calculus disease, normal limits of serum creatinine were observed majorly in a larger proportion (n=10,43.5%) of the population followed by highly elevated serum creatinine levels in 30.4% (n=7) and mildly elevated levels in 26.1% (n=6) of the patients.

The statistical analysis in the population of calculus diseases showed that urinary calcium levels were mildly elevated in a larger proportion 48% (n=11), highly elevated in some (30%, n=7) and moderately elevated in fewer patients (22%, n=5), in that order.

All the patients with the diagnosis of calculus disease were positive for acidic urine on investigation (100%).

A greater proportion of the population with calculus disease had the presence of uric acid stones (n=13,56.5%) on urine analysis than individuals without uric acid stones (n=10,43.5%).

A major percentage of the participants with calculus disease had presence of oxalate (n=16,69.6%) in the urine-on-urine analysis whereas the remaining proportion did not (n=7.30.4%).

A majority of patients had calculi on unilateral side (n=21,91.3%) whereas a fewer patients had bilateral calculi (n=2,8.7%).

Most of these patients had calculi on the right side (n=16, 69.6%), than on left (n=5, 21.7%).

The average age of the study population was estimated to be 66.4±6.5 years. The current investigation revealed that excluding calculus disease, the study included a higher proportion of male participants (71.4%) than female participants.

The study participants had other findings such as multiple cysts and ureterocoele in majority with an equivalent distribution of percentage of 28.6% (n=2) each constituting 4 participants in total, similarly, the rest participants also had an equal distribution of patients with pelvic tumours, psoas collection, and pyelonephritis in 14.3% (n=1) of the population each.

An elevated proportion of the study included patients had unilateral and bilateral involvement of lesion in 85.7% (n=6) and bilaterally in 14.3% (n=1).

The study revealed that the majority of the population had moderate

obstruction (57.1%, n=4) followed by mild obstruction (n=3,42. 9%). There was nil population with severe obstruction.

Assessment of diagnostic value of SS-FSE and 3D FSE sequences of Magnetic Resonance Urography individually in patients with Obstructive uropathy as compared to the correlative CT findings

The sequences of interest SS-FSE and 3D FSE of MRU were compared with correlative CT and respective findings of the various etiologies in patients with Obstructive uropathy (OU) were assessed to determine the diagnostic value independently**.** The study represented that SS-FSE were able to assess the etiology of OU to be renal calculi precisely and accurately in 7 patients (87.5%) out of total 8 patients with renal calculi, on the other hand, SS-FSE was capable of detecting all the ureteric calculi (n=15,100%) whereas the 3D-FSE of MRU weas able to completely assess the etiology of OU to be calculus disease precisely and accurately in all the 8 and 15 (100%) patients with renal calculi and ureteric calculi respectively.**(Table 4)** The overall diagnostic efficiency of SS-FSE and 3D FSE when assessed in combination is determined to be 95.7% (n=22) out of a total 23 calculus disease patients. Hence, the study demonstrated that overall diagnostic accuracy of SS-FSE and 3D FSE sequences when compared to the CT is almost similar individually. The study infers those 5 patients (21.7%) out of 23 study participants had multiple calculi, maximum 2 in number (78.3%), whereas the remaining population had only one calculus.

Remaining study population

The study indicated that both SS-FSE and 3D-FSE of MRU individually have the capacity to diagnose all the 7 patients comprising multiple cysts, pelvic tumours, psaos collections, pyelonephritis and ureterocoele more accurately and precisely, like that of correlated CT findings.

Assessment of obstruction

When evaluating the assessment of obstruction with grading of the sequences including SS-FSE and 3D-FSE techniques of Magnetic Resonance Urography (MRU) individually, it was inferred that there was certain disparity in the results which could be explained with merits and demerits of the sequence. SS-FSE has overestimated 20% (n=2) of mild grading to moderate grading when compared between the findings of SS-FSE and CT correlated validated results. Similarly, when compared the moderate grade of obstruction, SS-FSE with validated results of diagnosis by the CT correlated findings, the study results exhibited that SS-FSE has underestimated the grade of moderate to mild grade in 2 patients (16.7%, n=2) and overestimated the moderate grade to severe grade in 1 patient (8.3%, n=1). **(Table 5)** Identically, when comparing the grades of severe grades with respect to the single shot spin echo sequence and validated findings, it was detected that the severe grades of single shot spin echo sequence grading exactly matched the grading as assessed by validated results in 1 patient. But, when assessed with the CT validated findings with the three-dimensional echo sequence findings, it was noticed that there was an exact match between the findings of three-dimensional echo sequence findings and the validated results.

Hence, the investigation established that the grading of pathologies with SS-FSE and 3D-FSE of MRU is almost equivalent to that of CT correlated findings separately.

DISCUSSION

This study demonstrated that overall diagnostic accuracy of SS-FSE and 3D FSE sequences when compared to the CT is observed to be equivalent to that of CT correlated findings. When evaluating the assessment of obstruction with grading of the sequences including SS-FSE and 3D-FSE techniques of Magnetic Resonance Urography (MRU) individually, it was inferred that there was certain disparity in the results which could be explained with merits and demerits of the sequence.

Sen et al. (2008)[15] assessed the intravenous urography, ultra sonography, computed tomography and magnetic resonance imaging are in vogue to detect the cause and demonstrate the site of obstruction on 25 patients similar to our study only in the assessment of MRU but with larger sample size. The reported study assessed the etiology of obstructive uropathy to be calculus in 85% of the study population, whereas our study had demonstrated the overall diagnostic efficiency of SS-FSE and 3D FSE was almost equivalent to that of CT correlated findings. Moreover, the published data also demonstrated 100% of tumor detection in the studied population, identical to our study. The rest of the findings were excluded in our investigation. The published investigation had established that MRU has greater accuracy, like our investigation. Beyond the study of Sen et al.[15,] our investigation has further added that three-dimensional fast echo sequence provides more reliable tool in MRU which could even identify the grades of obstruction more precisely and accurately than single shot fast spin echo sequence particularly and moreover, the study has observed any variation with respect to etiology between the studied sequences of investigations. Unlike the study of Sen et al.[15] our study had analyzed the sequence tools within MRU for the precision of etiology identification and obstruction grading analysis.

According to Regan et al.[16] HASTE MR can accurately differentiate between acute and chronic ureteric obstructions based on the intensity of the perirenal high signal, and it has an accuracy rate of 87% in diagnosing the existence of acute ureteric obstruction in agreement with our investigation where the sensitivity of diagnosing renal calculi was also found to 100% individually.

In pregnant women, children, and patients who are allergic to contrast medium, Jung et al. found that MRU boosted with gadolinium and frusemide was effective for dilating the system without having any excretory activity [17] in contrast to our interest of investigation. The simultaneous use of T2-weighted and 3D fast low-angle shot sequence promised good characteristics for detecting acute suspected renal colic, according to Sudah et al.[18] T2-weighted sequences were not linked with significant diagnostic value for patients who suffered from flank pain, similar to our investigation. According to Shokeir et al.[19], MRU displayed improved detection ability for identifying non-calculous lesions in patients with renal impairment introduced on by ureteral obstruction, while non-contract computerized tomography has good diagnostic accuracy for identifying the causes of calculus obstruction.

According to Regan et al. [20], the combination of fluid and ureteric dilatation on MRU had sensitivity, specificity, and accuracy of 93%, 95%, and 94%, respectively in contrast, our study had documented the sensitivity and specificity to be 100%. Combining those studies suggests that MRU has a higher diagnostic value for detecting ureteric blockages in adults. Using diuretics or fluids has demonstrated the sensitivity and the specificity of the MRU to be 100% without diuretics.

CONCLUSION

Calculus obstruction (76.7%) was found to be the most common etiology causing Obstructive uropathy (OU) in study population with distal ureter (39%) being most common point of obstruction. The study concludes that both the Magnetic Resonance Urography (MRU) sequences of single shot fast echo and three-dimensional fast spin echo sequence have significantly high diagnostic value in identifying etiology and grading OU. Further advancements in MRU sequences can play a major role in developing a comprehensive protocol or even single step investigation for evaluation of Obstructive uropathy.

LIST OF TABLES AND FIGURES

Table 1: Distribution of patients based on age groups.

S.No	Age groups (years)	Frequency	Percentage (%)
1.	≤ 30	5	16.7
2.	31 to 40	5	16.7
3.	41 to 50	3	10.0
4.	51 to 60	4	13.3
5.	61 to 70	9	30.1
6.	≥71	4	13.3

Table 2: Description of etiology of obstructive uropathy elucidated by MRU (n=30).

Etiology of obstructive uropathy	Frequency	Percentage
Multiple cysts	2	6.7
Pelvic tumors	1	3.3
Psoas collection	1	3.3
Pyelonephritis	1	3.3
Renal calculi	8	26.7
Ureteric calculi	15	50
Ureterocele	2	6.7

Table 3: Delineation of the extent of obstruction in calculus disease.

Hydronephrosis degree	Frequency (n)	Percentage (%)
Mild	10	43.5
Moderate	11	47.8
Severe	2	8.7
Total	23	100%

Table 4: Description of etiology findings as observed in the study sequence of MRU among the calculus patients with respect to the CT correlated findings.

CT correlated and validated findings	SS-FSE	3D FSE
Etiology		
Renal calculi (n=8)	7 (87.5%)	8 (100%)
Ureteric calculi (n=15)	15 (100%)	15 (100%)

Table 5: Assessment of grading the obstruction between the study sequence with the validates results among the calculus patients individually.

Hydronephrosis grading	Three-dimensional fast spin-echo sequence (MRU)		
Single shot spin echo sequence (MRU)	Mild (n=10)	Moderate(n=11)	Severe (n=2)
Mild (n=10)	8 (80%)	2 (20%)	0 (0%)
Moderate (n=12)	2 (16.7%)	9 (75.0%)	1 (8.3%)
Severe (n=1)	0	0	1 (100%)

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