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Original Article

Radiology Section

Diagnostic Efficacy of Magnetic Resonance Imaging versus Computed Tomography in Characterisation of Renal Infections

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ABSTRACT

Introduction: Urinary Tract Infections (UTI) are one of the most frequently diagnosed infections worldwide, accounting for patient morbidity at any age group. It can affect both the upper and lower urinary tract. Over the past decade, a variety of Magnetic Resonance Imaging (MRI) methods have been developed and applied to many renal diseases. Current advances in MRI techniques have enabled the non-invasive investigation of renal disease.

Aim: To evaluate the efficacy of MRI in diagnosing renal infections and compare the diagnostic performance and accuracy of MRI with Contrast Enhanced Computed Tomography (CECT) in characterising renal infections.

Materials and Methods: It was a hospital based cross-sectional study, conducted on total 30 patients (age group 20-70 years, 6 males and 24 females) who came to the Department of Radiology of the institute from January 2019 to October 2019, with clinical suspicion of renal infections and showed positive radiological findings in CECT that were suggestive of renal infections. Magnetic Resonance- Kidney Urinary Bladder (MR-KUB) region was performed for all the patients by 128 slice CT scanner and 1.5 Tesla MRI scanners. Special sequences like Diffusion Weighted Imaging (DWI) MRI were employed and images acquired were analysed radiographically and were reviewed to compare their ability to find various UTIs. The collected data were analysed using Statistical Package for Social Sciences (SPSS) version 23.0. Descriptive statistics frequency and percentage and mean±SD was used for analysis of the collected data. Sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) were calculated to compare the tools.

Results: The current study comprised of 30 patients with male to female ratio 1:4 and 46.66% patients from 41-50 years age group. MRI along with DWI showed sensitivity of 88.46% in detecting intrinsic parenchymal signal changes, and sensitivity of 100% in detecting abscess formation, intra/extra parenchymal, perinephric fluid collections, micro-abscesses, large foci of air and obstructive calculi, whereas it was less sensitive in detecting non-obstructive calculi and tiny air foci. Non-Contrast CT (NCCT) was able to diagnose renal infection in 12 out of 30 patients with sensitivity of 40%. Conventional MRI diagnosed renal infection in 21 of these 30 patients with sensitivity of 70%, DWI was able to show the changes in 27 patients with sensitivity of 90% in comparison to the cases prediagnosed with CECT.

Conclusion: MRI has higher sensitivity than non-contrast enhanced CT for detection of renal infections. DW MRI is equally sensitive in detecting renal infections, compared to contrast enhanced CT, and is more sensitive compared to conventional MR imaging. DWI can also be used to differentiate pyonephrosis from hydronephrosis and in early detection of micro-abscesses.

Keywords: Contrast enhanced computed tomography, Diffusion weighted imaging, Radiological findings, Urinary tract infections

INTRODUCTION

The UTIs are one of the most frequently diagnosed infections worldwide accounting for patient morbidity at any age group. It can affect both the upper and lower urinary tract. UTIs originate typically in the bladder and ascend to the upper urinary tract or it can be seeded hematogenously [1], after which tubulo-interstitial inflammation develops and involves the renal parenchyma and pelvis. This condition is characterised as pyelonephritis [2].

In adults, diagnosing renal infections typically is based on characteristic clinical findings and abnormal laboratory investigations. Imaging is generally indicated for patients who present with complicated UTIs. UTIs are said to be uncomplicated when they occur in young and healthy people, non-pregnant women and in those infections which respond well to the antibiotic therapy. Diagnostic imaging is not indicated in this population. However, when imaging is done, the nature and extent of the disease and the complications such as abscess or obstruction can be demonstrated. For patients with complicated infections, imaging can be useful in deciding appropriate therapy, medical or surgical, thereby preventing unfavourable or potentially catastrophic outcomes [1]. Complicated and uncomplicated pyelonephritis, xanthogranulomatous pyelonephritis, and genito-urinary tuberculosis are all UTIs for which imaging evaluation needs diagnostic information important for patient care [1].

Multidetector CT, before and after contrast injection, is the preferred diagnostic modality for evaluating renal infections. CT is also preferred over conventional imaging modalities like radiography and ultrasound for assessing emphysematous pyelonephritis. Recurrent bacterial infections result in xanthogranulomatous pyelonephritis, a chronic granulomatous process for which CT is the main imaging modality as it provides highly specific findings. Extra renal spread and extent of the disease is accurately assessed by CT, which is essential for planning surgery [2].

Over the past decade, a variety of MRI methods have been developed and applied to many renal diseases. These techniques show great promise, enabling the non-invasive assessment of renal structure, function, and injury in individual subjects. For a long time, its use has been restricted, because of its long acquisition time, high cost and low availability [3]. Current advances in MRI techniques have enabled the non-invasive investigation of renal disease. Further development, evaluation, and application of the MRI

techniques should facilitate better understanding and assessment of renal disease and the development of new imaging biomarkers, enabling the intensified treatment to high-risk populations and a more rapid interrogation of novel therapeutic agents and protocols [4,5]. The aim of the present study was to evaluate the efficacy of MRI in diagnosing renal infections and also compare the diagnostic performance and accuracy of MRI with CECT in characterising renal infections.

MATERIALS AND METHODS

The present study was a hospital based, cross-sectional study conducted on total 30 patients in the Department of Radiology, Chettinad Hospital and Research Institute, Kelambakkam, Chennai from January 2019 to October 2019 after approval by the Human Ethical Committee of the Institution (proposal no: 178/IHEC/1-19).

Inclusion criteria: Patients in age group 20-70 years, who came to the department during the study time period, with clinical suspicion of renal infections, and showed positive radiological findings in CECT (parenchymal density changes, parenchymal abscess, pyonephrosis and perinephric collections) that are suggestive of renal infections, were included in the study after taking proper informed consent.

Exclusion criteria: Patients who were contraindicated for MRI and patients who does not had positive findings were excluded.

Sample size calculation: According to Rathod SB et al, the DW MRI has a sensitivity of 95.3% in detecting pyelonephritis compared to contrast CT [5]. Considering the above mentioned values, the sample size was calculated using the following formula at a precision of 3.5% and at 99% confidence interval. On subsitituting the values in the below formula, the sample size calculated comes to 30 samples.

The study was performed in a PHILIPS 128 slice CT scanner and GE SIGNA 1.5 Tesla MRI scanner. Routine MRI sequences used were axial T1 Fast Spin Echo (FSE), axial T2 Fast Recovery Fast Spin Echo (FRFSE), coronal T1 FSE, coronal T2 FRFSE and axial T2 fat saturated sequences, special sequences like DWI MRI were also employed. The images obtained were subjected to radiological analysis and interpretation. The images from the screening and diagnostic imaging investigations were reviewed to compare their ability to find various UTIs.

STATISTICAL ANALYSIS

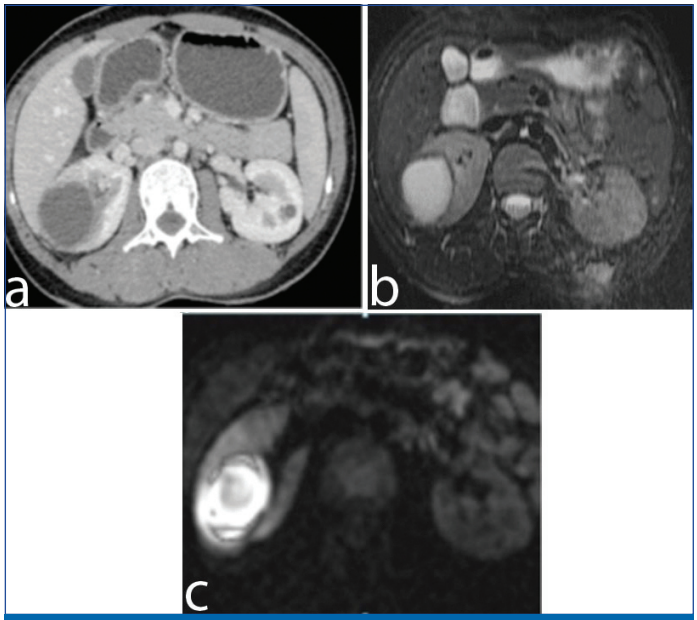
The collected data were analysed with International Business Machines (IBM) SPSS statistics software version 23.0. To describe the data, descriptive statistics frequency and percentage analysis was used for categorical variables and the mean±SD was used for continuous variables. To find the efficacy of the tools, the sensitivity, specificity, PPV and NPV were used.

RESULTS

Majority of the study population (around 80%) were females, with male to female ratio 1:4. Most of the study population (46.66%) belonged to the age group of 41-50 years. A 30% of non-emphysematous pyelonephritis had diabetes mellitus. This large difference could be due to variation in the study design and number of samples. Majority (70%) of the patients in the study group had unilateral involvement of the kidney. Bilateral involvement was seen in 9 out of 30 patients (30%).

Sensitivities of NCCT, conventional MRI and DW alone in the detection of pyelonephritis: Out of 30 patients who participated in the study, on CECT, 26 patients (86.6%) were found to have intrinsic parenchymal density changes. Out of these 26 patients, NCCT was able to detect density changes in 8 patients (26.7%) with sensitivity of 30%. On conventional MRI, parenchymal changes were seen in 16 cases (53.3%) with sensitivity of 61.4%, whereas DWI detected signal changes in 22 patients (73.3%) out of these 26 patients, with sensitivity of 84.6%.

On CECT, 3 patients (10%) were found to have parenchymal abscess, which were identified in both conventional and diffusion weighted MR imaging, with sensitivity and specificity of 100% [Table/Fig-1], whereas the authors could not appreciate the abscess formation in NCCT in any of these patients.



[Table/Fig-1]: A 45-year-old diabetic female with intraparenchymal abscess in the right kidney a) and b) axial CECT and T2 FRFSE MRI showing a thick walled parenchymal cystic lesion in the right kidney. c) DW MRI Demonstrating central restriction. Percutaneous Nephrostomy was done and drainage of pus confirmed abscess.
CECT: Contrast enhanced computed tomography; FRFSE: Fast recovery fast spin echo; MRI: Magnetic resonance imaging; DW: Diffusion weighted

Out of 3 patients (10%) who had perinephric fluid collection/abscess formation in CECT, NCCT picked up the lesion in 2 patients (6.7%) with sensitivity of 66.67%, whereas both conventional MRI and DWI were able to pick up the finding in all three cases with sensitivity of 100%.

Micro-abscesses were found in 5 (16.7%) out of 30 patients in CECT, whereas DWI picked up micro-abscess in 6 (20%) out of 30 patients. NCCT and conventional MRI sequences failed to pick up the micro-abscesses in any of these cases [Table/Fig-2].

Micro-abscesses	NCCT	CECT	cMRI	DWI
Present	0	5	0	6
Absent	30	25	30	24
Total	30	30	30	30

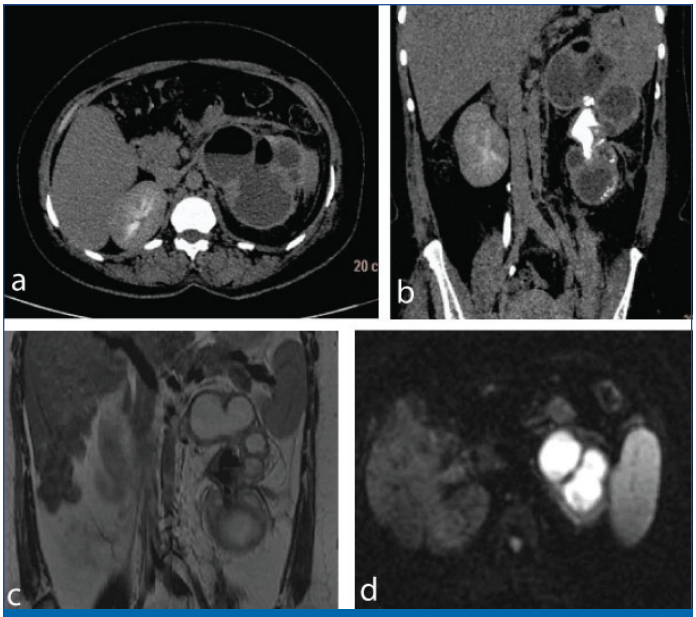
[Table/Fig-2]: Comparison of diagnostic accuracy of various cross-sectional modalities in detection of micro-abscesses.
NCCT: Non-contrast computed tomography; cMRI: conventional magnetic resonance imaging; DWI: Diffusion weighted imaging

Two out of these 30 cases, two had pyonephrosis in CECT. DWI was able to pick up pyonephrosis in these patients with sensitivity and specificity of 100% [Table/Fig-3]; whereas NCCT and conventional MRI sequences were not able to differentiate pyonephrosis from hydronephrosis in these patients.

Pyonephrosis	NCCT	CECT	cMRI	DWI
Present	0	2	0	2
Absent	30	28	30	28
Total	30	30	30	30

[Table/Fig-3]: Comparison of diagnostic accuracy of various cross-sectional modalities in detection of pyonephrosis.

One patient had obstructive calculus which was best seen in NCCT, and was picked up by MRI as well [Table/Fig-4]. Eleven patients (37%) had non-obstructive renal calculi, which were only seen in CT. MRI failed to detect any of these non-obstructive renal calculi.



[Table/Fig-4]: A 34-year-old female a) and b) Axial and Coronal Contrast Enhanced CT (CECT) demonstrating enlarged left kidney, grossly dilated calyces with air-fluid levels and large obstructive pelviureteric junction calculus; c) MRI Coronal T2 FRFSE showing hydronephrosis and calculus; d) DWI showing restricted diffusion, suggestive of pyonephrosis.

Three out of 30 patients, 10% were found to have air foci i.e., emphysematous pyelonephritis in CT. MRI was able to demonstrate the air foci in two out of these three cases. Tiny air foci could not be clearly appreciated. In this current study of 30 patients, MRI along with DWI showed sensitivity of 88.46% in detecting intrinsic parenchymal signal changes, and sensitivity of 100% in finding out abscess formation, intra/extra-parenchymal, perinephric fluid collections, micro-abscesses, large foci of air and obstructive calculi, whereas it was less sensitive in detecting non-obstructive calculi and tiny air foci. Taking all these parameters into account, NCCT was able to diagnose renal infection in 12 out of 30 patients with sensitivity of 40%. Conventional MRI diagnosed renal infection in 21 of these 30 patients with sensitivity of 70%. DWI alone was able to show the changes in 27 patients with sensitivity of 90%.

Out of these 30 patients, four patients with parenchymal/perinephric abscesses had undergone drainage and antibiotic therapy. Two patients with lesions smaller than 3 cm were managed conservatively with antibiotics. Patients with only intrinsic parenchymal signal changes and micro-abscesses were managed conservatively. Out of three patients with emphysematous pyelonephritis, two patients had undergone nephrectomy, among which one also had obstructive staghorn calculus, who was then diagnosed to have tuberculous aetiology. One patient with emphysematous pyelonephritis was managed with drainage and antibiotic therapy.

DISCUSSION

In the present study, 30% patients had bilateral involvement of kidney, this was in concordance with the prospective study of Kumar S et al., with 35% of their study group reported to have bilateral involvement [4]. Contrast CT study was able to detect morphological changes in 28 patients with a sensitivity of 66.7% for the detection of pyelonephritis, which was higher than the present study where NCCT had 40% sensitivity in picking up the signal changes. In his study, 27 out of 42 patients (64.3%) had signal changes in conventional MRI, similar to that of the present study. Out of 42 patients in his study, 40 patients showed diffusion restriction with sensitivity of 95%, which is in concordance with the present study where DWI had sensitivity of ~90%.

In an animal study done by Majd M et al., it was found that the sensitivity of MRI in detecting pyelonephritis is 89.5% [6]. This is in concordance with the present study in which MRI along with DWI showed sensitivity of 90%. De Pascale A et al., studied 242 patients and found that the sensitivity of DWI MRI in picking up renal infection is 95% [7], the results pretty similar to the present study. Whereas in a study conducted by Vivier PH et al., in children, DWI showed 100% sensitivity in detection of pyelonephritis [8].

Albarello F et al., conducted a prospective study on 55 patients, out of which DWI MRI demonstrated restricted diffusion in 42 patients with sensitivity of 75% which is lesser compared to this study which had sensitivity of 90% [9]. Also in his study, in DWI, renal abscesses were detected in 2 out of 55 cases (3%), whereas in the present study of 30 patients, 10% had renal abscess [9]. In a study done on 21 patients by Henninger B et al., DWI demonstrated obvious signal changes in 18 out of 21 patients with sensitivity of 86%, similar to the present study [10].

Goyal A et al., compared MDCT, conventional MRI and MRI with DWI in evaluation of focal renal lesions and found that MRI along with DWI had the highest accuracy rate of 94% in definitive diagnosis of focal renal lesions and ~98% of the lesions were diagnosed with higher confidence level, significantly better than MDCT and conventional MRI. In this study, out of 25 abscess cases, both conventional MRI and MRI with DWI were able to detect the abscesses in all these 25 cases, with sensitivity of 100%. In this study as well, both conventional MRI and DWI were able to pick-up the findings in all three cases which were positive in CECT [11].

Various previous studies had reported that CT had the sensitivity of 95 to 100% in detecting calculi. As in this study as well, CT was able to pick-up the calculus effectively, with sensitivity of 100% [12-20]. Studies by Ali M and Bashir Barlas N; Narlawar RS et al., Huang JJ and Tseng CC, and Mongha R et al., had reported higher sensitivities of 95 to 100% in detecting air foci [21-24]. These results were similar to the present study, however MRI was less sensitive in detecting air foci.

As CT is often increasingly recognised as a major source of radiation, experts recommend replacing MDCT with other options, when practical, like MRI. In the setting of renal infections, where many non-oncologic patients and young patients are being examined, this is of higher significance. Especially for the paediatric population, where the comparable dose of radiation is higher than adults, MRI seems to be a perfect alternative, particularly DWI, as it has the advantage of radiation free imaging with high robustness to motion, as this can be done even during continuous breathing. However, for visualisation of calculi and air foci, CT is still the gold standard and should be done in cases with suspicion of emphysematous pyelonephritis and any calculus pathology.

Limitation(s)

The present study had small sample size inclusion of cases that are only positive in contrast enhanced CT subjecting to selection bias. Follow-up imaging after treatment was not done. Histopathological/surgical correlation was done only in a few patients.

CONCLUSION(S)

The most common findings documented in the present study were intrinsic parenchymal changes followed by micro-abscess formation. There was female preponderance in the overall proportion of patients referred for evaluation of pyelonephritis and majority of the subjects belonged to 40 to 50 years age group with diabetes mellitus as the commonly associated co-morbidity. MRI has higher sensitivity than NCCT for detection of renal infections. DW MRI is equally sensitive in detecting renal infections, compared to contrast enhanced CT, and is more sensitive compared to conventional MR imaging. DWI can also be used to differentiate pyonephrosis from hydronephrosis. Generally, imaging is not routinely required for diagnosis and treatment of uncomplicated cases. However, when images are obtained, they demonstrate the extent and nature of the disease and reveal the complication such as obstruction or abscess formation. Currently, CT remains the mainstay investigation in evaluating renal

infections. However, NCCT fails to detect the pathology in most of the cases. Multidetector CT, before and after contrast injection, is the preferred diagnostic modality for evaluating renal infections. CT is also preferred over conventional imaging modalities like radiography and ultrasound for assessing emphysematous pyelonephritis. MRI is recommended in pregnant women, children, transplant recipients, immunocompromised patients and patients with contraindications for contrast administration. Further development, evaluation, and application of the MRI techniques should facilitate better understanding and assessment of renal disease and the development of new imaging biomarkers, enabling the intensified treatment to high-risk populations and a more rapid interrogation of novel therapeutic agents and protocols.

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