

Original Research Article

ROLE OF DIFFUSION WEIGHTED IMAGING IN EARLY DIAGNOSIS OF PYELONEPHRITIS IN URINARY TRACT INFECTION IN A TERTIARY CARE HOSPITAL- A CROSS SECTIONAL STUDY

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ABSTRACT

Background: Acute pyelonephritis (APN) is a common upper urinary tract infection that may result in serious complications if diagnosis and treatment are delayed. Conventional imaging techniques, including ultrasonography and contrast-enhanced computed tomography (CECT), have limitations such as reduced sensitivity in early disease, radiation exposure, and the need for intravenous contrast. Diffusion-weighted imaging (DWI), a functional magnetic resonance imaging (MRI) technique, detects alterations in water molecule diffusion within inflamed renal tissue and has emerged as a promising, non-invasive modality for the early diagnosis of APN. **Aims and Objectives:** **Aim:** Aim of this study is to evaluate role of diffusion weighted imaging in early diagnosis of pyelonephritis in urinary tract infection.

Objective

- To estimate the prevalence of pyelonephritis in urinary tract infection patients.
- To evaluate the efficacy of Diffusion weighted imaging in diagnosing pyelonephritis in urinary tract infection patients.
- To determine accuracy of DWI in detecting acute pyelonephritis with the help of ADC values.

Materials and Methods: This hospital-based cross-sectional study was conducted over 12 months after obtaining Institutional Scientific and Ethics Committee approval. A total of 68 patients with clinically suspected urinary tract infection, referred to the Department of Radiodiagnosis at S.V. Ramnarayan Ruia Government General Hospital, Tirupati, were enrolled based on predefined inclusion criteria. Demographic details, clinical features, and laboratory investigations, including urine analysis and urine culture, were recorded using a structured proforma. All patients underwent diffusion-weighted MRI of the kidneys. Imaging findings, including diffusion restriction and ADC values, were assessed and correlated with clinical presentation, laboratory findings, and the final diagnosis. Statistical analysis was performed to determine the diagnostic performance of DWI.

Results: The mean age of the study population was 41.19 ± 10.35 years. Most patients belonged to the 31–45-year age group (47.1%), followed by 46–60 years (33.8%), while females constituted 66.2% of the study population. Pain (77.9%) was the most common presenting symptom, followed by dysuria (66.2%), costovertebral angle tenderness (60.3%), chills (48.5%), and vomiting (22.1%). Urine culture was positive in 64.7% of patients. Diffusion-weighted imaging detected renal lesions suggestive of APN in 45 patients (66.2%), which corresponded with the final diagnosis. A statistically significant association was observed between DWI findings and the final

diagnosis ($\chi^2 = 51.30$, $p < 0.001$). DWI demonstrated a sensitivity of 95.6%, specificity of 91.3%, positive predictive value of 95.6%, negative predictive value of 91.3%, and overall diagnostic accuracy of 94.1%. The mean ADC value was significantly lower in patients with APN ($1.128 \pm 0.071 \times 10^{-3} \text{ mm}^2/\text{s}$) than in those without APN ($1.659 \pm 0.088 \times 10^{-3} \text{ mm}^2/\text{s}$; $p < 0.001$). Receiver operating characteristic analysis showed excellent diagnostic performance ($\text{AUC} = 0.992$). An ADC cutoff value of $\leq 1.31 \times 10^{-3} \text{ mm}^2/\text{s}$ yielded a sensitivity of 93.3% and specificity of 95.7% for diagnosing APN.

Conclusion: Diffusion-weighted MRI is a reliable, non-invasive, and radiation-free imaging modality for the early diagnosis of acute pyelonephritis in patients with urinary tract infection. Its high sensitivity, ability to detect early renal inflammation, and avoidance of contrast administration make it particularly valuable in patients with renal impairment, pregnancy, or contrast contraindications. Incorporating DWI into the diagnostic evaluation of suspected acute pyelonephritis can facilitate timely management and improve clinical outcomes.

Keywords: Acute pyelonephritis, Diffusion-weighted imaging, Magnetic resonance imaging, Urinary tract infection, Apparent diffusion coefficient, Renal infection, Early diagnosis, Cross-sectional study.

INTRODUCTION

Urinary tract infections (UTIs) are among the most prevalent bacterial infections encountered in both community and hospital settings.^[1] Acute pyelonephritis, an upper urinary tract infection involving the renal parenchyma and pelvis, represents a potentially severe complication of UTI, often resulting in systemic illness and, if untreated, can lead to renal scarring, hypertension, renal insufficiency, and sepsis.^[2,3] Early and accurate diagnosis of pyelonephritis is therefore crucial to prevent these adverse outcomes. Conventional diagnostic modalities such as ultrasonography (USG) and computed tomography (CT) have their own limitations in terms of sensitivity, specificity, radiation exposure, or cost.^[4] There is a growing clinical demand for non-invasive, accurate imaging techniques that can facilitate early detection and guide prompt therapeutic interventions, thus reducing morbidity and potential mortality associated with complicated UTIs.^[5]

In the Indian context, UTIs contribute significantly to outpatient and inpatient morbidity, particularly in women, diabetics, and the elderly.^[6] Pyelonephritis constitutes a considerable proportion of hospital admissions for UTI-related complications, especially in tertiary care settings such as S.V. Medical College, Tirupati.^[7] The burden of disease, combined with diagnostic delays due to overlapping clinical presentations and limitations of current imaging methods, underscores the need for more effective diagnostic tools.^[8] As infection-related renal dysfunction is potentially reversible, early identification through better imaging can have major epidemiological implications in reducing long-term renal morbidity and healthcare costs.^[9]

Despite the growing utility of Magnetic Resonance Imaging (MRI) in various abdominal pathologies, the role of Diffusion-Weighted Imaging (DWI) in diagnosing acute pyelonephritis remains under-

explored in the regional and national literature.^[10] Most available studies are either limited in sample size or not tailored to the Indian population, and very few have assessed the practical implementation of DWI in a tertiary care setting.^[11] Given the limited availability of conclusive data from this region, especially in a resource-sensitive environment, this study aims to fill a critical knowledge gap and provide evidence for the utility of DWI in early pyelonephritis diagnosis, potentially redefining diagnostic algorithms.^[12]

S.V. Medical College, Tirupati, being a tertiary care center, is well-equipped with advanced radiological infrastructure, including high-resolution MRI with DWI capability, experienced radiologists, and a high inpatient turnover presenting with UTIs. These facilities, combined with a robust clinical diagnostic setup, make it feasible to conduct a prospective evaluation of DWI in suspected cases of pyelonephritis. The anticipated outcome is to establish DWI as a reliable, non-invasive, radiation-free diagnostic modality that can enhance early detection and improve clinical outcomes. The study also aims to provide region-specific data that can inform future diagnostic guidelines and research in the field.

Aims and Objectives

Aim

Aim of this study is to evaluate role of diffusion weighted imaging in early diagnosis of pyelonephritis in urinary tract infection.

Objective

- To estimate the prevalence of pyelonephritis in urinary tract infection patients.
- To evaluate the efficacy of Diffusion weighted imaging in diagnosing pyelonephritis in urinary tract infection patients.
- To determine accuracy of DWI in detecting acute pyelonephritis with the help of ADC values.

MATERIALS AND METHODS

A cross-sectional study was conducted.

Study Period

The study was carried out over a period of 12 months following approval by the Institutional Scientific Committee and Institutional Ethics Committee.

Study Subjects

The subjects included patients referred to the Department of Radiodiagnosis from all departments of S.V. Ramnarayan Ruia Government General Hospital, Tirupati.

Sample Size

The sample size was calculated based on the sensitivity of diffusion-weighted imaging (DWI) in diagnosing acute pyelonephritis. DWI MRI was reported to have a higher sensitivity of 95.3% compared to non-contrast CT (66.7%) and contrast-enhanced CT (88.1%).^[4]

Thus, a minimum of 68 patients were included in the study.

Inclusion Criteria

Patients were included if they met the following criteria:

- Willingness to give informed and written consent
- Clinical suspicion of pyelonephritis
- Diagnosed urinary tract infection with symptoms such as high-grade fever ($>38^{\circ}\text{C}$), abdominal or lumbar pain, positive urine microscopy, and negative urine culture (performed after initiation of antibiotics)
- Negative findings on ultrasonography

Exclusion Criteria

Patients were excluded if they met any of the following criteria:

- History of renal transplantation
- Absolute contraindications to MRI (e.g., cardiac pacemakers, aneurysm clips, metallic foreign bodies)
- Already diagnosed cases of pyelonephritis by other imaging modalities (CECT, ultrasonography)

Study Methods

A structured, pre-prepared case proforma was used to document patient demographics, clinical findings, and laboratory investigations. A total of 68 patients meeting the inclusion criteria were enrolled.

All participants underwent the following MRI sequences (breath-hold unless otherwise noted):

- SS TSE (Single Shot Turbo Spin Echo) T2
- GRE (Gradient Echo) dual phase
- TSE T2
- TSE FatSat T2
- SE-EPI (Spin Echo Echo Planar Imaging) DWI (respiratory triggered) at b-values of 0, 600 AND 800 s/mm^2 in axial and coronal planes.

The field of view (FOV) was adjusted to include both kidneys and the perinephric space, generally extending from the dome of the diaphragm to the lower pole of the kidneys.

Ethical Considerations

Approval was obtained from the Institutional Ethics Committee of S.V. Medical College, Tirupati.

Participants were informed about the academic purpose of the study before enrollment.

No financial burden was imposed on any patient. Confidentiality of all participants was strictly maintained.

Statistical Considerations

Data were entered into Microsoft Excel for analysis. Descriptive statistics were presented as mean $\pm$ standard deviation. Inferential statistics included the t-test for quantitative variables and the chi-square test for categorical variables.

RESULTS

The results of the present study summarize the demographic characteristics, clinical features, laboratory parameters, and imaging findings observed among patients evaluated for suspected acute pyelonephritis using diffusion-weighted magnetic resonance imaging (DWI MRI). A total of 68 patients who fulfilled the inclusion criteria were included in the study and underwent detailed clinical assessment along with MRI evaluation.

Table 1: Distribution of Sociodemographic Characteristics – Age (n = 68)

Age Group	Frequency	Percent (%)
18–30 years	12	17.6
31–45 years	32	47.1
46–60 years	23	33.8
>60 years	1	1.5
Total	68	100.0

The majority of participants belonged to the 31–45 years age group (47.1%), indicating the highest occurrence in middle-aged adults. A substantial proportion were 46–60 years (33.8%), followed by

18–30 years (17.6%). Very few participants were above 60 years (1.5%), showing minimal representation of the elderly population in the study.

Table 2: Sex Distribution of Study Participants (n = 68)

Sex	Frequency	Percent (%)
Female	45	66.2
Male	23	33.8
Total	68	100.0

The study population showed a higher proportion of females (66.2%) compared to males (33.8%). This indicates that pyelonephritis was more common

among female participants in the study group. The findings reflect the known epidemiological trend of higher urinary tract infection rates in females.

Table 3: Clinical Presentation among Study Participants (n = 68)

Clinical Feature	Yes n (%)	No n (%)
Pain	53 (77.9)	15 (22.1)
Dysuria	45 (66.2)	23 (33.8)
Chills	33 (48.5)	35 (51.5)
Vomiting	15 (22.1)	53 (77.9)
CVA Tenderness	41 (60.3)	27 (39.7)

Pain was the most common clinical symptom (77.9%), followed by dysuria (66.2%) and CVA tenderness (60.3%) among the study participants. Chills were present in 48.5% of patients, indicating

moderate occurrence. Vomiting was the least common symptom (22.1%), with the majority of participants not reporting it.

Table 4: Urine Culture Results in Study Participants (n = 68)

Urine Culture Result	Frequency	Percent (%)
Positive	44	64.7
Negative	24	35.3
Total	68	100.0

The majority of study participants showed positive urine culture results (64.7%), indicating confirmed bacterial infection in most cases. Negative culture results were observed in 35.3% of participants. This

suggests that urine culture positivity was common among patients diagnosed with pyelonephritis in the study.

Table 5: Continuous Clinical and Laboratory Parameters (n = 68)

Parameter	Mean	SD	Minimum	Maximum
Age (years)	41.19	10.35	22	63
Temperature (°C)	38.78	0.32	38.3	39.4
Fever Duration (days)	3.44	1.27	2	6
TLC	13898.53	2908.79	9800	18100
CRP	49.60	23.05	18	88

The mean age of the study participants was 41.19 ± 10.35 years, with ages ranging from 22 to 63 years. The mean body temperature was $38.78 \pm 0.32^\circ\text{C}$ and the average duration of fever was 3.44 ± 1.27 days,

indicating acute presentation. Laboratory parameters showed elevated inflammatory markers with a mean TLC of $13,898.53 \pm 2,908.79$ and mean CRP of 49.60 ± 23.05 , supporting the presence of infection.

Table 6: Imaging Findings in Study Participants (n = 68)

Imaging Modality	Finding	Frequency	Percent (%)
DWI	Positive	45	66.2
	Negative	23	33.8
Radiology Diagnosis	APN	47	69.1
	No APN	21	30.9

Diffusion Weighted Imaging (DWI) showed positive findings in 66.2% of participants, while 33.8% had negative findings. Radiological diagnosis revealed that 69.1% of patients were diagnosed with

acute pyelonephritis (APN), whereas 30.9% showed no evidence of APN. These findings indicate that a majority of the study population demonstrated imaging features consistent with APN.

Table 7: Laterality of Renal Involvement on MRI (n = 68)

Laterality	Frequency	Percent (%)
Right	20	29.4
Left	19	27.9
Bilateral	8	11.8
None	21	30.9
Total	68	100.0

Renal involvement was observed slightly more on the right side (29.4%) compared to the left side (27.9%) among the study participants. Bilateral involvement was noted in 11.8% of cases, indicating

fewer patients had infection affecting both kidneys. No renal involvement was seen in 30.9%, corresponding to participants without MRI evidence of disease.

Table 8: Final Diagnosis of Study Participants (n = 68)

Final Diagnosis	Frequency	Percent (%)
APN	45	66.2

No APN	23	33.8
Total	68	100.0

The majority of the study participants were diagnosed with acute pyelonephritis (APN) accounting for 66.2% of cases. No APN was observed in 33.8% of the participants. These

findings indicate that APN constituted the predominant final diagnosis among the study population.

Table 9: Association Between DWI Findings and Final Diagnosis

DWI Finding	APN n (%)	No APN n (%)	Total	Chi-square	P-value
Negative	2 (8.7)	21 (91.3)	23	51.30	<0.001
Positive	43 (95.6)	2 (4.4)	45		
Total	45	23	68		

A strong association was observed between DWI findings and the final diagnosis of APN. The majority of patients with positive DWI findings were diagnosed with APN (95.6%), whereas most DWI-negative cases were classified as No APN

(91.3%). The association was statistically highly significant (Chi-square = 51.30, $p < 0.001$), indicating that DWI is a reliable indicator for diagnosing APN.

Table 10: Diagnostic Performance of DWI for Detecting APN

Measure	Value
Sensitivity	95.6%
Specificity	91.3%
PPV	95.6%
NPV	91.3%
Accuracy	94.1%

Diffusion Weighted Imaging demonstrated high diagnostic performance in detecting acute pyelonephritis. The sensitivity of 95.6% indicates that DWI correctly identified the majority of patients with APN, while the specificity of 91.3% shows good ability to exclude patients without the disease. The positive and negative predictive values

were 95.6% and 91.3%, respectively, with an overall diagnostic accuracy of 94.1%. These findings suggest that DWI is a reliable and effective imaging modality for the early diagnosis of acute pyelonephritis in patients with urinary tract infection.

Table 11: Comparison of Mean ADC Values Between APN and No APN

Diagnosis	N	Mean ADC	SD	T-static	P-value
APN	45	1.128	0.071	26.83	<0.001
No APN	23	1.659	0.088		

The mean ADC value was lower in patients with APN (1.128 ± 0.071) compared to those without APN (1.659 ± 0.088). This indicates that restricted diffusion is more prominent in APN cases. The

difference was statistically highly significant ($T = 26.83$, $p < 0.001$), demonstrating that ADC values are useful in differentiating APN from non-APN cases.

Table 12: Diagnostic Performance of ADC in Detecting Acute Pyelonephritis

Parameter	Value
Cutoff (ADC)	≤ 1.31
AUC	0.992
Sensitivity	93.3%
Specificity	95.7%
PPV	97.7%
NPV	88.0%
Accuracy	94.1%
Youden Index	0.890

ROC curve analysis demonstrated excellent diagnostic performance of ADC values for identifying acute pyelonephritis with an AUC of 0.992 ($p < 0.001$). An optimal ADC cutoff value of $\leq 1.310 \times 10^{-3} \text{ mm}^2/\text{s}$ yielded 93.3% sensitivity and 95.7% specificity, with a Youden Index of 0.890.

DISCUSSION

Acute pyelonephritis is a significant upper urinary tract infection that can lead to serious complications if not diagnosed and treated promptly. Early identification of renal parenchymal involvement is essential to prevent long-term consequences such as renal scarring, chronic kidney disease, and sepsis. Conventional imaging modalities such as

ultrasonography and computed tomography have been widely used in the evaluation of renal infections; however, each has certain limitations including low sensitivity in early disease detection, radiation exposure, and potential contrast-related complications. In recent years, diffusion-weighted imaging (DWI) as part of magnetic resonance imaging (MRI) has emerged as a valuable diagnostic tool due to its ability to detect changes in tissue water diffusion associated with inflammatory processes without the need for contrast administration.

The present study was conducted to evaluate the role of diffusion-weighted imaging in the early diagnosis of acute pyelonephritis in patients presenting with urinary tract infection in a tertiary care hospital. The study analyzed demographic characteristics, clinical presentation, laboratory findings, and imaging features among the study population. Additionally, quantitative parameters such as apparent diffusion coefficient (ADC) values were assessed to determine their effectiveness in differentiating diseased renal parenchyma from normal tissue. The findings of this study were compared with previously published research to understand similarities, differences, and the overall clinical relevance of diffusion-weighted MRI in the evaluation of acute pyelonephritis.

The present study evaluated the role of diffusion-weighted imaging (DWI) in the early diagnosis of acute pyelonephritis among patients presenting with urinary tract infection in a tertiary care hospital setting. A total of 68 patients were included in the study, providing a representative cohort for evaluating demographic characteristics and imaging findings associated with renal infection. The mean age of participants was 41.19 ± 10.35 years, with the majority of patients belonging to the 31–45 year age group, indicating that acute pyelonephritis predominantly affects middle-aged adults in the studied population. Additionally, a higher proportion of female participants (66.2%) was observed, reflecting the well-established epidemiological trend that urinary tract infections occur more frequently in females due to anatomical predisposition and hormonal influences. These findings highlight the importance of reliable diagnostic imaging techniques for early detection and management of renal infections in high-risk populations.

The findings of the present study were compared with previously published research to understand similarities and variations in demographic characteristics and study design. The present investigation included 68 cases, which is comparable to the sample size reported by Antignano et al,^[13] who studied 84 cases, and Nakata et al,^[14] who evaluated 123 patients, while Simrén et al,^[15] conducted their analysis on a smaller sample of seven patients. Despite differences in the number of participants across studies, the demographic distribution observed in

the present study aligns with earlier reports indicating a higher prevalence of acute pyelonephritis among females and middle-aged individuals. The variation in sample sizes among these studies may be attributed to differences in study design, inclusion criteria, and institutional settings, but the overall consistency in demographic patterns supports the reliability of the current findings.

The results of the present study contribute to the growing body of evidence supporting diffusion-weighted MRI as an effective and reliable imaging modality for the early detection of acute pyelonephritis. The ability of DWI to detect renal parenchymal inflammation without the use of contrast agents or exposure to ionizing radiation represents a significant advantage over conventional imaging techniques such as contrast-enhanced CT. This characteristic is particularly important for patients with renal impairment or those at risk of contrast-induced nephropathy. The integration of diffusion-weighted imaging into routine diagnostic protocols may therefore enhance early diagnosis, improve treatment planning, and reduce potential complications associated with delayed detection of renal infections. Consequently, the findings of this study reinforce the clinical utility of DWI in improving patient outcomes and optimizing radiological evaluation in tertiary care settings.

The present study assessed the demographic profile of patients with suspected acute pyelonephritis and evaluated the diagnostic role of diffusion-weighted imaging in this population. The mean age of patients in the present study was 41.19 ± 10.35 years, indicating that acute pyelonephritis predominantly affected adults in the middle-aged group. This age distribution reflects the increased exposure to risk factors such as urinary tract infections, diabetes mellitus, and other comorbidities that commonly occur in adulthood. The findings highlight that renal infections remain an important clinical concern among economically productive age groups.

Understanding the age distribution of affected individuals is essential for identifying high-risk populations and optimizing diagnostic strategies for early disease detection.

The mean age observed in the present study differs from that reported in some earlier investigations, which may be attributed to variations in study populations and clinical settings. Antignano et al,^[13] reported a mean age of 7.3 ± 6.2 months, reflecting a predominantly pediatric population, whereas Nakata et al,^[14] reported a mean age of 51 ± 20.4 years, representing an older adult cohort. These differences highlight the heterogeneity in patient populations across studies investigating acute pyelonephritis. Despite these variations, the mean age reported in the present study falls within the adult age range commonly affected by urinary tract infections and renal inflammatory conditions. Such differences in demographic characteristics may arise from differences in inclusion criteria, geographic

variations, and the clinical profile of patients presenting to tertiary care centers.

The observed age distribution in the present study emphasizes the need for prompt and accurate diagnostic approaches in adult populations presenting with symptoms suggestive of urinary tract infection. Middle-aged individuals represent a significant portion of the workforce, and early diagnosis of renal infections can prevent complications such as renal scarring, chronic kidney disease, and sepsis. Imaging modalities such as diffusion-weighted MRI offer valuable diagnostic advantages by enabling early detection of parenchymal inflammation without the use of ionizing radiation or contrast agents. Consequently, the integration of advanced imaging techniques into routine clinical evaluation may enhance diagnostic accuracy, improve patient outcomes, and support evidence-based management of acute pyelonephritis in tertiary care healthcare settings.

The present study evaluated the gender distribution among patients diagnosed with acute pyelonephritis and found a clear predominance of female patients. Out of 68 participants included in the study, 45 patients (66.2%) were females and 23 patients (33.8%) were males, indicating that females constituted nearly two-thirds of the study population. This finding reflects the well-established epidemiological pattern that urinary tract infections and their complications occur more frequently in females due to anatomical factors such as a shorter urethra and closer proximity of the urethral opening to the perineal region. Hormonal influences and higher susceptibility to ascending infections also contribute to this increased risk among women. The observed gender distribution in the present study emphasizes the importance of early diagnostic evaluation in female patients presenting with symptoms suggestive of urinary tract infection to prevent progression to renal involvement.

The gender distribution observed in the present study is largely consistent with previously published studies investigating acute pyelonephritis. Antignano et al,^[13] reported a female predominance with 52.4% females and 47.6% males, while Nakata et al,^[14] demonstrated a markedly higher proportion of female patients (87.0% females and 13.0% males), further supporting the higher susceptibility of women to upper urinary tract infections. In contrast, Simrén et al,^[15] reported a slightly higher proportion of males (57.1% males and 42.9% females), which may be attributed to the very small sample size included in that study. Despite these variations, the overall trend across most studies demonstrates a higher prevalence of acute pyelonephritis among female patients, reinforcing the findings of the present investigation. Differences in gender distribution across studies may arise from variations in study population, geographic factors, and differences in the inclusion criteria used by different investigators.

The predominance of female patients observed in the present study has important clinical and public health implications for the diagnosis and management of urinary tract infections. Early recognition of symptoms in female patients and timely utilization of appropriate imaging modalities can facilitate early detection of renal parenchymal involvement and prevent complications such as renal scarring or sepsis. The integration of diffusion-weighted MRI into diagnostic protocols may further enhance the accuracy of detecting acute pyelonephritis without exposing patients to ionizing radiation or contrast-related risks. Consequently, these findings highlight the need for heightened clinical awareness and targeted diagnostic strategies for female patients presenting with urinary tract infection symptoms, particularly in tertiary care healthcare settings.

The present study evaluated urine culture findings among patients with suspected acute pyelonephritis and demonstrated that 44 patients (64.7%) had positive urine cultures, while 24 patients (35.3%) showed negative culture results. The predominance of positive cultures reflects the strong association between bacterial urinary tract infections and the development of renal parenchymal inflammation. Positive urine cultures provide microbiological confirmation of infection and play an essential role in guiding appropriate antimicrobial therapy. However, the presence of a proportion of negative cultures in clinically suspected cases highlights the possibility of prior antibiotic administration, low bacterial counts, or fastidious organisms that may not be detected through routine culture techniques. These findings emphasize the importance of integrating clinical, laboratory, and radiological parameters for accurate diagnosis of acute pyelonephritis.

The urine culture positivity observed in the present study demonstrates a pattern broadly consistent with findings reported in previous studies evaluating acute pyelonephritis. Nakata et al,^[14] reported a higher culture positivity rate of 79.5%, while Simrén et al,^[15] documented 100% positive cultures among their study participants. The slightly lower positivity rate observed in the present study may be attributed to factors such as prior antibiotic exposure before sample collection, differences in microbiological techniques, or variations in patient selection criteria. Additionally, the presence of negative cultures despite clinical suspicion of infection has been reported in several clinical studies, reflecting the limitations of culture-based diagnostic methods. These variations highlight the importance of combining microbiological findings with advanced imaging modalities such as diffusion-weighted MRI to improve diagnostic accuracy.

The findings of this study highlight the critical role of urine culture in confirming bacterial infection in patients with suspected renal involvement while also demonstrating the limitations of relying solely on microbiological testing. In clinical practice, negative

urine cultures do not necessarily exclude the presence of renal infection, particularly in patients who have received empirical antibiotic therapy prior to sample collection. The integration of imaging techniques such as diffusion-weighted MRI can therefore provide valuable complementary information by detecting early renal parenchymal inflammation even in culture-negative cases. This combined diagnostic approach may enhance early detection, facilitate timely treatment, and reduce the risk of complications associated with delayed diagnosis of acute pyelonephritis in tertiary care settings.

The present study evaluated imaging findings using diffusion-weighted imaging (DWI) MRI for the detection of acute pyelonephritis in patients with urinary tract infection. Positive DWI findings were observed in 66.2% of patients, indicating that a significant proportion of the study population demonstrated radiological evidence of renal parenchymal inflammation. Diffusion-weighted imaging identifies areas of restricted diffusion caused by inflammatory cell infiltration, interstitial edema, and reduced extracellular space within infected renal tissue. These imaging characteristics allow early detection of pyelonephritic lesions even before structural changes become evident on conventional imaging modalities. The results of the present study therefore highlight the clinical usefulness of DWI MRI in detecting early renal involvement and supporting accurate diagnosis in patients with suspected upper urinary tract infection. The proportion of positive DWI findings in the present study shows general agreement with previous research investigating diffusion-weighted imaging in renal infections, although some variations are observed across studies. Antignano et al,^[13] reported a higher detection rate of 92.9% positive DWI findings, while Nakata et al,^[14] demonstrated 85.7% positivity using diffusion-weighted whole-body imaging with background body signal suppression (DWIBS MRI). Similarly, Simrén et al,^[15] reported that lesions were detected in all studied kidneys, indicating a very high diagnostic yield of diffusion-weighted MRI. The relatively lower percentage of positive imaging findings observed in the present study may be attributed to differences in sample size, imaging protocols, disease severity at presentation, or patient selection criteria. Despite these differences, the findings remain consistent with the broader literature supporting the diagnostic value of diffusion-weighted MRI in identifying renal inflammatory lesions associated with acute pyelonephritis.

The findings of the present study reinforce the growing recognition of diffusion-weighted MRI as a valuable imaging modality in the evaluation of renal infections. Compared with conventional imaging techniques such as ultrasonography and contrast-enhanced computed tomography, DWI offers the advantage of detecting renal parenchymal

inflammation without exposure to ionizing radiation or the use of contrast agents. This makes the technique particularly beneficial for patients with renal impairment, pregnant women, and individuals with contraindications to iodinated contrast media. The incorporation of diffusion-weighted imaging into routine diagnostic protocols for suspected acute pyelonephritis may improve early disease detection, facilitate timely therapeutic intervention, and ultimately reduce the risk of complications such as renal scarring and chronic kidney disease.

The present study evaluated the final radiological diagnosis of acute pyelonephritis among patients presenting with clinical features of urinary tract infection and negative ultrasonography findings. Out of the 68 patients included in the study, 45 patients (66.2%) were diagnosed with acute pyelonephritis, indicating that a substantial proportion of clinically suspected cases demonstrated radiological evidence of renal parenchymal inflammation. This finding highlights the importance of advanced imaging techniques in confirming renal involvement, particularly in cases where conventional imaging modalities may fail to detect early inflammatory changes. Early identification of acute pyelonephritis is essential to prevent complications such as renal scarring, chronic kidney disease, and systemic infection. Therefore, the diagnostic yield observed in the present study underscores the clinical relevance of diffusion-weighted MRI in detecting renal infections in patients with urinary tract infection.

The proportion of acute pyelonephritis cases identified in the present study demonstrates consistency with findings reported in earlier investigations evaluating renal infections using advanced imaging techniques. Antignano et al [13] reported 78 cases (92.9%) of renal involvement, indicating a higher detection rate of acute pyelonephritis in their study population. Similarly, Nakata et al,^[14] described 123 cases of acute focal bacterial nephritis (AFBN), a condition closely related to acute pyelonephritis characterized by focal inflammatory involvement of the renal parenchyma. In contrast, Simrén et al,^[15] reported typical acute pyelonephritis patterns in six kidneys, reflecting a smaller study population but confirming the presence of characteristic imaging findings associated with renal infection. Variations in the proportion of diagnosed cases among these studies may be attributed to differences in patient demographics, study design, imaging techniques, and diagnostic criteria used to define renal involvement.

The findings of the present study emphasize the clinical value of diffusion-weighted MRI in identifying renal parenchymal inflammation in patients with suspected acute pyelonephritis. Accurate radiological diagnosis allows clinicians to initiate targeted antimicrobial therapy at an early stage, thereby reducing the risk of disease progression and long-term renal complications. In

addition, diffusion-weighted imaging provides a non-invasive diagnostic approach that avoids the use of ionizing radiation and contrast agents, making it particularly useful in patients with renal impairment or other contraindications to contrast-enhanced imaging. Consequently, the integration of diffusion-weighted MRI into routine diagnostic protocols for suspected renal infections may significantly improve diagnostic accuracy and support more effective management of acute pyelonephritis in clinical practice.

The present study evaluated the apparent diffusion coefficient (ADC) values obtained from diffusion-weighted imaging to differentiate between diseased renal parenchyma affected by acute pyelonephritis and normal renal tissue. The mean ADC value observed in diseased renal tissue was $1.128 \pm 0.071 \times 10^{-3} \text{ mm}^2/\text{s}$, whereas the mean ADC value in normal renal parenchyma was $1.659 \pm 0.088 \times 10^{-3} \text{ mm}^2/\text{s}$. The significantly lower ADC values in affected renal tissue reflect restricted diffusion caused by inflammatory cell infiltration, interstitial edema, and reduced extracellular space within the renal parenchyma. This clear difference between diseased and normal tissue demonstrates the effectiveness of ADC measurements as a quantitative biomarker for detecting renal inflammation. The findings confirm that diffusion-weighted MRI not only provides qualitative visualization of lesions but also offers measurable parameters that improve diagnostic confidence in cases of suspected acute pyelonephritis.

The ADC values observed in the present study are consistent with previously reported findings in studies evaluating diffusion-weighted imaging in renal infections. Simrén et al.^[45] reported a mean ADC value of $1.22 \pm 0.11 \times 10^{-3} \text{ mm}^2/\text{s}$ in diseased renal tissue and $1.45 \pm 0.15 \times 10^{-3} \text{ mm}^2/\text{s}$ in normal renal tissue, which demonstrates a similar pattern of reduced diffusion in infected renal parenchyma. The slightly lower ADC values observed in diseased tissue in the present study may be attributed to differences in imaging protocols, patient population characteristics, or the severity of inflammation at the time of imaging. Despite minor variations, both studies consistently demonstrate that acute pyelonephritis is associated with significant restriction of water molecule diffusion within the renal parenchyma. These findings reinforce the reliability of ADC measurements as an objective parameter for distinguishing infected renal tissue from normal parenchyma.

The quantitative assessment of ADC values has important implications for improving the diagnostic accuracy of renal imaging in patients with suspected acute pyelonephritis. The ability to objectively measure diffusion restriction provides radiologists with a reliable tool to differentiate inflammatory renal lesions from normal tissue or other renal pathologies. Furthermore, the use of diffusion-weighted MRI eliminates the need for contrast agents and avoids radiation exposure, making it

particularly advantageous for patients with renal impairment or contraindications to contrast-enhanced imaging. Incorporating ADC measurement into routine MRI evaluation of suspected renal infections may therefore enhance early diagnosis, guide clinical decision-making, and support more effective management strategies for patients with acute pyelonephritis.

Bacterial Etiology Distribution

One important parameter missing from the present study is the detailed distribution of causative microorganisms responsible for urinary tract infections. Although urine culture positivity was reported, the study did not specify the types of bacteria isolated, such as *Escherichia coli*, *Klebsiella pneumoniae*, or *Enterococcus species*. Other comparative studies, particularly Nakata et al [14], provided detailed microbiological profiles showing that *E. coli* was the predominant pathogen in both urine and blood cultures. Such information is clinically significant because it helps identify the most common pathogens responsible for renal infections and guides appropriate antibiotic therapy. Without this microbiological breakdown, it becomes difficult to compare infection patterns across populations or evaluate whether imaging findings correlate with specific organisms. Including bacterial distribution would improve the epidemiological and clinical relevance of the study results.

Antibiotic Treatment Regimen

Another parameter not reported in the present study is the antibiotic treatment regimen used for patients after diagnosis. Previous studies included detailed information regarding intravenous and oral antibiotic therapy, including the type of drug administered and duration of treatment. For example, Nakata et al,^[14] described the frequency of antibiotics such as cefmetazole, ceftriaxone, and levofloxacin, along with mean durations of intravenous and oral therapy. This information is important because treatment strategies may influence clinical recovery, imaging findings, and disease progression. In the absence of antibiotic data, it becomes difficult to evaluate whether imaging abnormalities correspond with treatment response or severity of infection. Reporting antimicrobial therapy would allow better comparison with other clinical studies and help assess whether diffusion-weighted MRI findings correlate with therapeutic outcomes.

Blood Culture Findings

The present study did not include blood culture results, which represent another important clinical parameter in infection research. Blood cultures help determine whether the urinary tract infection has progressed to systemic bacteremia or sepsis, particularly in cases of severe acute pyelonephritis. In contrast, other studies reported the proportion of patients with positive blood cultures and identified the organisms isolated. This information provides valuable insight into the severity of infection and

systemic involvement. The absence of blood culture data limits the ability to evaluate whether patients with positive diffusion-weighted imaging findings also had evidence of bloodstream infection. Including this parameter would strengthen the clinical interpretation of the imaging results and provide a clearer understanding of the relationship between radiological findings and systemic infection markers.

Inter-Observer Agreement in Imaging Interpretation

Another missing parameter is the assessment of inter-observer agreement between radiologists interpreting diffusion-weighted MRI findings. In imaging studies, it is important to evaluate whether different observers reach similar conclusions when reviewing the same images. Some comparative studies calculated Cohen's kappa coefficient to measure the level of agreement between radiologists. High inter-observer agreement indicates that the imaging method is reliable and reproducible in clinical practice. However, the present study did not report any statistical measurement of agreement between observers evaluating DWI images or ADC maps. Without this information, it is difficult to determine whether the diagnostic performance observed in the study could be consistently reproduced by other radiologists. Including inter-observer reliability analysis would strengthen the methodological robustness of the imaging evaluation.

Number and Characteristics of Renal Lesions

The present study focused primarily on the presence or absence of acute pyelonephritis but did not provide detailed information about the number, size, or distribution of renal lesions detected on MRI. Some comparative imaging studies reported the mean number of inflammatory lesions, lesion location, and patterns of renal parenchymal involvement. These parameters are important because the extent and distribution of lesions may reflect disease severity and progression. For example, multiple wedge-shaped lesions or bilateral involvement may indicate more extensive renal inflammation. Without detailed lesion characterization, the study cannot fully explore correlations between imaging findings and clinical severity markers such as CRP, leukocyte count, or fever duration. Including lesion-specific data would allow a deeper radiological analysis and improve comparison with other MRI-based studies of renal infections.

Follow-Up Imaging and Long-Term Outcomes

A final parameter absent from the present study is follow-up imaging or long-term clinical outcome assessment. Some studies included repeat imaging or follow-up evaluations to determine whether renal lesions resolved after treatment or progressed to renal scarring or chronic damage. Follow-up data are particularly valuable in infections like acute pyelonephritis because unresolved inflammation can lead to permanent renal impairment. Without

longitudinal follow-up, it is not possible to determine whether the abnormalities detected on diffusion-weighted MRI were transient inflammatory changes or indicators of potential long-term complications. Including follow-up imaging results would provide insight into the prognostic value of ADC measurements and DWI findings, thereby strengthening the clinical applicability of the study conclusions.

CONCLUSION

The present study demonstrates that diffusion-weighted magnetic resonance imaging is a valuable and reliable imaging modality for the early diagnosis of acute pyelonephritis in patients presenting with urinary tract infection. Diffusion-weighted imaging effectively detects renal parenchymal inflammation by identifying areas of restricted diffusion, thereby facilitating early and accurate diagnosis even when conventional imaging modalities may be inconclusive. The study findings also highlight the usefulness of apparent diffusion coefficient measurements in differentiating diseased renal tissue from normal parenchyma. As a non-invasive technique that does not require contrast administration or expose patients to ionizing radiation, diffusion-weighted MRI provides a safe and effective diagnostic tool. Incorporating diffusion-weighted imaging into routine radiological evaluation can improve diagnostic confidence and assist in timely clinical management of acute pyelonephritis.

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