

**American College of Radiology
ACR Appropriateness Criteria®
Acute Pyelonephritis**

Variant 1: **Acute pyelonephritis. Uncomplicated patient (eg, no history of diabetes or immune compromise or history of stones or obstruction or prior renal surgery or lack of response to therapy). Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography intravenous urography	Usually Not Appropriate	☼ ☼ ☼
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☼ ☼
Radiography abdomen and pelvis (KUB)	Usually Not Appropriate	☼ ☼
Fluoroscopy antegrade pyelography	Usually Not Appropriate	☼ ☼ ☼
US color Doppler kidneys and bladder retroperitoneal	Usually Not Appropriate	O
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☼ ☼ ☼ ☼
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☼ ☼ ☼
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☼ ☼ ☼
Tc-99m DMSA scan kidney	Usually Not Appropriate	☼ ☼ ☼

Variant 2:**Acute pyelonephritis. Complicated patient (eg, diabetes or immunocompromised or history of stones or prior renal surgery or not responding to therapy). Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☼ ☼ ☼
CT abdomen and pelvis without and with IV contrast	Usually Appropriate	☼ ☼ ☼ ☼
MRI abdomen without and with IV contrast	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☼ ☼ ☼
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate (Disagreement)	O
MRI abdomen and pelvis without IV contrast	May Be Appropriate	O
MRI abdomen without IV contrast	May Be Appropriate	O
US color Doppler kidneys and bladder retroperitoneal	May Be Appropriate	O
Tc-99m DMSA scan kidney	May Be Appropriate	☼ ☼ ☼
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☼ ☼
Radiography abdomen and pelvis (KUB)	Usually Not Appropriate	☼ ☼
Fluoroscopy antegrade pyelography	Usually Not Appropriate	☼ ☼ ☼
Radiography intravenous urography	Usually Not Appropriate	☼ ☼ ☼

ACUTE PYELONEPHRITIS

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Summary of Literature Review

Introduction/Background

Urinary tract infections (UTIs) are among the most common infections affecting humans [1]. In most adults, the infection is confined to the lower urinary tract (LUT), diagnosis is established by clinical or laboratory studies and imaging studies are not required. When the kidney itself is involved or when there is difficulty in differentiating LUT infection from renal parenchymal involvement, imaging studies are often requested, both for diagnosis and to plan management. Conditions that are thought to predispose a patient with LUT infection to renal involvement include vesicoureteral reflux, altered bladder function, congenital urinary tract anomalies, and the presence of renal calculi.

Pathologically, inflammatory disease of the kidney generally occurs as the result of ascending infection from the LUT (regardless of whether radiologically demonstrated vesicoureteral reflux is present) by gram-negative enteric pathogens (usually *Escherichia coli*) and is known as acute pyelonephritis. Less commonly, it could result from seeding of the kidneys from hematogenous spread of a bacterial infection. The term “pyelonephritis” accurately reflects the underlying pathologic condition present (ie, infection involving both the renal parenchyma and the renal pelvis). In most patients, uncomplicated pyelonephritis is readily diagnosed clinically and responds quickly to treatment with appropriate antibiotics. If treatment is delayed, the patient is immunocompromised, or, for other reasons that are poorly understood, small microabscesses that form during the acute phase of pyelonephritis may coalesce to form an acute renal abscess. If such an abscess then ruptures into the perinephric space, a perirenal abscess is formed. If the infection is confined to an obstructed collecting system, the term “pyonephrosis” may be used, and prompt decompression is required.

Patients with underlying diabetes are of particular concern as they are more vulnerable to complications from acute pyelonephritis, including renal abscesses and emphysematous pyelonephritis [2]. Additionally, it is also more difficult to establish the diagnosis on clinical grounds in diabetics because as many as 50% will not have the typical flank tenderness that helps to differentiate pyelonephritis from LUT infection in an otherwise healthy patient [3,4]. Additional higher-risk populations may include those with an anatomic abnormality of the urinary tract, vesicoureteral reflux, renal obstruction, pregnancy, nosocomial infection, infections by treatment-resistant pathogens, transplant recipients, and immunosuppressed patients [5]. Treatment goals include symptom relief, elimination of infection to avoid permanent renal damage (which may lead to scarring, hypertension, and end-stage renal disease), and identification of any precipitating factors to avoid future recurrences [5].

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Discussion of Procedures by Variant

Variant 1: Acute pyelonephritis. Uncomplicated patient (eg, no history of diabetes or immune compromise or history of stones or obstruction or prior renal surgery or lack of response to therapy). Initial imaging.

Radiography Intravenous Urography

Intravenous urography (IVU) is not indicated for initial evaluation of acute pyelonephritis in the uncomplicated patient [2].

Fluoroscopy Voiding Cystourethrography

Voiding cystourethrography (VCUG) is not indicated for initial evaluation of acute pyelonephritis in the uncomplicated patient [2].

Radiography Abdomen and Pelvis (KUB)

Abdominal radiographs (ie, abdomen and pelvis [KUB]) are not indicated for initial evaluation of acute pyelonephritis in the uncomplicated patient [2].

Fluoroscopy Antegrade Pyelography

Antegrade pyelography is not indicated for initial evaluation of acute pyelonephritis in the uncomplicated patient [2].

CT Abdomen and Pelvis

CT is not indicated for initial evaluation of acute pyelonephritis in the uncomplicated patient [2,6,7]. Furthermore, Soulen et al [7] confirmed the validity of waiting for 72 hours prior to obtaining imaging in a study of the usefulness of CT in patients with pyelonephritis. In this series, 95% of patients with uncomplicated pyelonephritis became afebrile within 48 hours of appropriate antibiotic therapy, and nearly 100% did so within 72 hours.

MRI Abdomen

MRI is not indicated for initial evaluation of acute pyelonephritis in the uncomplicated patient [2].

MRI Abdomen and Pelvis

MRI is not indicated for initial evaluation of acute pyelonephritis in the uncomplicated patient [2].

US Color Doppler Kidneys and Bladder Retroperitoneal

Ultrasound (US) is not indicated for initial evaluation of acute pyelonephritis in the uncomplicated patient [2].

Tc-99m DMSA Scan Kidney

Tc-99m-labeled dimercaptosuccinic acid (DMSA) renal scintigraphy is not indicated for initial evaluation of acute pyelonephritis in the uncomplicated patient [2].

Variant 2: Acute pyelonephritis. Complicated patient (eg, diabetes or immunocompromised or history of stones or prior renal surgery or not responding to therapy). Initial imaging.

Radiography Intravenous Urography

In the past, IVU was the primary diagnostic modality for imaging patients with renal infection. Its role has been essentially replaced with the increasing use of CT and/or MRI, which provide superior information [2,8].

Fluoroscopy Voiding Cystourethrography

VCUG can be used to demonstrate vesicoureteral reflux, but it is most frequently performed in children, particularly in the setting of recurrent febrile UTIs [9]. While these patients may benefit from a VCUG, it is not indicated in the acute setting. Rather, VCUG is usually performed after resolution of acute symptoms in order to assess for any underlying anatomic causes that could account for the recurrent infections. Adult women with predisposing factors suggesting risk of vesicoureteral reflux may also benefit [10].

Radiography Abdomen and Pelvis (KUB)

Abdominal radiographs (KUB) have very limited usefulness in the setting of acute pyelonephritis, unless large coexisting staghorn or obstructing calculi are being followed.

Fluoroscopy Antegrade Pyelography

Retrograde pyelography has limited usefulness in the initial evaluation, but it can be of value in patients with severe infection and obstruction that cannot be demonstrated noninvasively; it could be performed alongside a therapeutic intervention. Antegrade pyelography could be used as an alternative to a retrograde study.

CT Abdomen and Pelvis

There has been widespread agreement that CT is the imaging study of choice to diagnose patients with pyelonephritis who have a complex clinical presentation or do not respond to antibiotic therapy, and to look for potential complications such as a renal or perinephric abscess or emphysematous pyelonephritis [2,4,7,11-17]. It is a sensitive method for evaluating the complications of pyelonephritis, and it also provides a global assessment of involvement within the abdomen and pelvis [13]. CT is also very sensitive in evaluating for urolithiasis [13]. In addition to providing superior anatomic detail and improved sensitivity for detecting underlying congenital or acquired renal abnormalities, the use of intravenous (IV) contrast may provide additional information about the kidney, including renal perfusion and function. Contrast-enhanced CT has high sensitivity in detecting parenchymal changes in acute pyelonephritis, including early in the course of disease [2,8,13,14]. In most of the studies comparing CT with US, much of the additional benefit of CT lay in its ability to detect parenchymal abnormalities in patients with pyelonephritis that are generally missed by US [2,13]. Advantages of CT over MRI include the better ability to detect calculi [2,18,19] and to detect gas in emphysematous pyelonephritis [2,19]. CT can also show evidence of chronic pyelonephritis including renal scarring, atrophy and cortical thinning, hypertrophy of residual normal tissue, calyceal clubbing or dilatation, and renal asymmetry [2].

However, CT should not be obtained early in uncomplicated cases. Soulen et al [7] confirmed the validity of waiting for 72 hours prior to obtaining imaging in a study of the use of CT in patients with pyelonephritis. In this series, 95% of patients with uncomplicated pyelonephritis became afebrile within 48 hours of appropriate antibiotic therapy, and nearly 100% did so within 72 hours.

Regarding CT protocols, many studies to date have been performed using multiphase CT urography, including precontrast, postcontrast nephrographic (typically at 90–100 seconds), and excretory phases. Other authors have recommended the use of two phases, namely precontrast and nephrographic, unless obstruction is suspected [2,8]. A recent retrospective study by Taniguchi et al [20] showed that scans using only the nephrographic phase had similar accuracy with triphasic scans (which also included precontrast and excretory phases) for the diagnosis of acute pyelonephritis and urolithiasis. This study reported an accuracy of nephrographic phase only CT of 90% to 92% in the diagnosis of acute pyelonephritis and 96% to 99% in the diagnosis of urolithiasis. More studies, including prospective and case-controlled studies are needed to confirm these findings, particularly given the importance of reducing radiation dose associated with CT. Sites that include precontrast series should consider reduced dose techniques for these images.

MRI Abdomen

MRI may be particularly useful in patients in whom the use of iodinated contrast material must be avoided (particularly those with contrast sensitivity), but case-controlled studies fully documenting its efficacy have yet to be published. Both dynamic postcontrast MR sequences and diffusion-weighted imaging (DWI) are very helpful. When IV contrast cannot be administered, DWI offers a viable alternative [21]. Vivier et al [21] found DWI and contrast-enhanced MRI to be of equivalent value in a study of pediatric patients. Several studies in adults have shown DWI to be useful in diagnosing uncomplicated pyelonephritis [19,22-24]. One study by Rathod et al [19] found a higher sensitivity of DWI (95%) compared with noncontrast CT (67%) and contrast-enhanced CT (88%) in the diagnosis of pyelonephritis. De Pascale et al [22] also reported a high sensitivity, specificity, and accuracy (each at 95%) with DWI in uncomplicated pyelonephritis. Areas of pyelonephritis show significantly lower apparent diffusion coefficient values than normal renal cortical parenchyma. Furthermore, renal abscesses show significantly lower apparent diffusion coefficient values than areas of pyelonephritis [19]. DWI may also help differentiate between pyonephrosis and hydronephrosis due to the lower apparent diffuse coefficient of debris in pyonephrosis, and this may be particularly helpful for pregnant patients in the second and third trimesters [25]. Studies have also shown DWI sequences to provide reproducible information regarding renal function [26]. At a minimum, DWI is a viable alternative to dynamic contrast-enhanced MRI or CT in instances where there are contraindications to administration of iodinated or paramagnetic contrast medium, including patients with renal insufficiency and pregnant or lactating women [22].

However, contrast-enhanced MRI sequences remain an integral part of most protocols. Faletti et al [23] found them to be superior to DWI in identifying complications of pyelonephritis, including focal abscesses. One potential disadvantage of MRI compared to CT is its inability to detect smaller calculi, especially when the stones are not surrounded by urine [13,18,19]. In addition, gas in emphysematous pyelonephritis is typically less well seen with MRI than on CT [19]. Similar to CT, MRI should not be obtained early in uncomplicated cases [7].

MRI Abdomen and Pelvis

In certain cases, MR urography (MRU) protocols, including the abdomen and pelvis, may be useful. Similar to CT, MRU may be useful for detecting and characterizing congenital anomalies of the kidneys and entire genitourinary tract in the pediatric and adult population [18]. MRU may allow for a comprehensive assessment of the kidneys, ureters, bladder, and surrounding structures [18]. MRU combines high spatial resolution with assessment of renal function and drainage. Several studies comparing MRU to DMSA renal scintigraphy for the detection of pyelonephritis and renal scarring have shown MRU to be at least equivalent or superior to DMSA renal scintigraphy [27-29]. MRU can distinguish among acute pyelonephritis, renal scarring, and renal dysplasia [30]. One potential disadvantage of MRI compared to CT is its inability to detect smaller calculi, especially when the stones are not surrounded by urine [13,18,19].

Most MRU protocols utilize IV contrast [18]. In certain cases, static-fluid MRU sequences could be performed without contrast [18]. Although they may provide less information, they may be particularly helpful in the evaluation of pregnant patients [18]. Similar to CT, MR should not be obtained early in uncomplicated cases [7].

US Color Doppler Kidneys and Bladder Retroperitoneal

US advantages include low-risk, rapid acquisition in a portable setting, such as bedside, and that it does not require the use of contrast material [13,31,32]. Color and power Doppler should be included to improve the sensitivity for acute pyelonephritis [15]. However, US can miss subtle changes of mild pyelonephritis and often underestimates the severity of renal involvement or perinephric extension [2,8,32]. Yoo et al [33] in a study of 147 patients with clinically suspected acute pyelonephritis by CT showed significantly higher sensitivity than color and power Doppler US. In some instances, US may also be limited in the definitive differentiation of calcification from intraparenchymal or collecting system gas [2].

With recent technical advances in US, such as tissue harmonic imaging and more recently the use of US contrast agents, the sensitivity of US in detecting subtle parenchymal abnormalities in pyelonephritis has increased [32,34]. Fontanilla et al [32] in a study of 48 patients showed clear improvement in the ability of contrast-enhanced US (CEUS) over gray-scale US in assessing focal pyelonephritis and renal abscesses; however, CT correlation was not provided in most cases. In a study by Mitterberger et al [35] comparing CEUS and contrast-enhanced CT in 100 patients with acute pyelonephritis, CEUS was reported to have a sensitivity of 98%, a specificity of 100%, a low false-negative rate of 2%, and no false-positives. However, based upon limitations of the study, further work in this area will be needed to confirm the accuracy of this newer technique before more specific recommendations can be considered.

Conventional grayscale US is particularly helpful in evaluating for hydronephrosis or pyonephrosis (ie, the presence of low-level echoes within the collecting system) [2,13], but CT and DWI-MRI may also provide this diagnosis [25].

Tc-99m DMSA Scan Kidney

Renal scintigraphy has a useful role in the pediatric population wherein it is often difficult to differentiate LUT infection from pyelonephritis. Furthermore, it is also particularly important to identify potentially correctable precipitating factors at a young age, such as reflux and congenital anatomic abnormalities, which could lead to repeated infections, scarring, and loss of kidney function [5]. Studies have shown DMSA renal scintigraphy in the pediatric population to be more sensitive for detecting pyelonephritis than US. Other studies have proposed routinely obtaining both renal US and DMSA renal scintigraphy in children after their first febrile UTI [36]. Power Doppler US has shown sensitivities and specificities approaching 90% in children with acute pyelonephritis [37,38]. A study by Sattari et al [39] suggests that CT is more accurate than DMSA renal scintigraphy in detecting involvement with acute pyelonephritis in adult patients. Cerwinka et al [28] found MRU to be superior to DMSA renal scintigraphy in the identification of renal scarring in children with vesicoureteral reflux and a history of pyelonephritis; furthermore, DMSA renal scintigraphy also appears to underestimate the degree of renal parenchymal damage. Other studies comparing MRU to DMSA renal scintigraphy for the detection of pyelonephritis and renal scarring have shown MRU to be at least equivalent or superior to DMSA renal scintigraphy [27,29].

Summary of Recommendations

- **Variant 1:** Diagnostic imaging is usually not appropriate for initial evaluation of acute pyelonephritis in the uncomplicated patient.

- **Variation 2:** CT abdomen and pelvis with IV contrast or CT abdomen and pelvis without and with IV contrast are usually appropriate for imaging complicated patients in the setting of acute pyelonephritis.

Summary of Evidence

Of the 40 references cited in the *ACR Appropriateness Criteria® Acute Pyelonephritis* document, all of them are categorized as diagnostic references including 3 well-designed studies, 6 good-quality studies, and 9 quality studies that may have design limitations. There are 22 references that may not be useful as primary evidence.

The 40 references cited in the *ACR Appropriateness Criteria® Acute Pyelonephritis* document were published from 1985 to 2017.

While there are references that report on studies with design limitations, 9 well-designed or good-quality studies provide good evidence.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel’s recommendation. “May be appropriate” is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the *ACR Appropriateness Criteria® Radiation Dose Assessment Introduction* document [40].

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	0 mSv	0 mSv
⊛	<0.1 mSv	<0.03 mSv
⊛ ⊛	0.1-1 mSv	0.03-0.3 mSv
⊛ ⊛ ⊛	1-10 mSv	0.3-3 mSv
⊛ ⊛ ⊛ ⊛	10-30 mSv	3-10 mSv
⊛ ⊛ ⊛ ⊛ ⊛	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies”.

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.