

American College of Radiology ACR Appropriateness Criteria®

Clinical Condition: Acute Pyelonephritis

Variant 1: Uncomplicated patient.

Radiologic Procedure	Rating	Comments	RRL*
X-ray intravenous urography	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	☢ ☢ ☢
X-ray voiding cystourethrography	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	☢ ☢
X-ray abdomen and pelvis (KUB)	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	☢ ☢
X-ray antegrade pyelography	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	☢ ☢ ☢
US kidneys and bladder retroperitoneal	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	O
MRI abdomen and pelvis without and with contrast	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	O
MRI abdomen and pelvis without contrast	1		O
CT abdomen and pelvis without and with contrast	1	If there is a role for imaging in some circumstance, this is most likely to provide the most information.	☢ ☢ ☢ ☢
CT abdomen and pelvis with contrast	1		☢ ☢ ☢ ☢
CT abdomen and pelvis without contrast	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours. May be used in the presence of a critical diagnosis where contrast material cannot be given.	☢ ☢ ☢ ☢
Tc-99m DMSA scan kidney	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	☢ ☢ ☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: Acute Pyelonephritis

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

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis without and with contrast	8		☢ ☢ ☢ ☢
CT abdomen and pelvis with contrast	8		☢ ☢ ☢ ☢
US kidneys and bladder retroperitoneal with KUB	6		☢ ☢
CT abdomen and pelvis without contrast	6		☢ ☢ ☢ ☢
MRI abdomen and pelvis without and with contrast	6	See statement regarding contrast in text under “Anticipated Exceptions.”	O
MRI abdomen and pelvis without contrast	4		O
X-ray voiding cystourethrography	3	Not part of initial evaluation but may be used subsequently to demonstrate clinically suspected reflux.	☢ ☢
Tc-99m DMSA scan kidney	3	Cannot differentiate renal parenchymal disease from perinephric process.	☢ ☢ ☢
X-ray abdomen and pelvis (KUB)	2	Does not provide sufficient information by itself to guide therapy.	☢ ☢
X-ray intravenous urography	2		☢ ☢ ☢
X-ray antegrade pyelography	1	Not an initial study.	☢ ☢ ☢
<u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

ACUTE PYELONEPHRITIS

Expert Panel on Urologic Imaging: Paul Nikolaidis, MD¹; David D. Casalino, MD²; Erick M. Remer, MD³; Jay T. Bishoff, MD⁴; Courtney A. Coursey, MD⁵; Manjiri Dighe, MD⁶; Steven C. Eberhardt, MD⁷; Stanley Goldfarb, MD⁸; Howard J. Harvin, MD⁹; Elizabeth Lazarus, MD¹⁰; John R. Leyendecker, MD¹¹; Mark E. Lockhart, MD, MPH¹²; Massoud Majd, MD¹³; Aytakin Oto, MD¹⁴; Christopher Porter, MD¹⁵; Parvati Ramchandani, MD¹⁶; Sheila Sheth, MD¹⁷; Raghunandan Vikram, MD.¹⁸

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), the 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 (whether or not radiologically demonstrated vesicoureteral reflux is present) by gram-negative enteric pathogens (usually *Escherichia coli*) and is known as acute pyelonephritis. This name accurately reflects the underlying pathologic condition present (ie, infection involving both the renal parenchyma and the renal pelvis). In the majority of 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 poorly understood reasons, small micro abscesses 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 infection is referred to as pyonephrosis. Patients with underlying diabetes are of particular concern, as they are more vulnerable to the development of a complication from acute pyelonephritis, including renal abscesses and emphysematous pyelonephritis. Additionally, it is also more difficult to establish the diagnosis on clinical grounds in diabetics, since as many as 50% will not have the typical flank tenderness that helps to differentiate pyelonephritis from LUT infection in an otherwise healthy patient [2,3].

Prior to the advent of cross-sectional imaging, radiologic studies performed in patients with uncomplicated pyelonephritis were normal in most cases. In the early 1970s, however, a subgroup of patients was identified with acute pyelonephritis, commonly with underlying diabetes, who did not respond quickly to therapy and in whom urography showed anatomic and severe functional abnormalities [4]. In order to differentiate such patients from those with garden-variety pyelonephritis, a new term, acute bacterial nephritis, was coined. With the advent of cross-sectional imaging, a whole new lexicon of terminology evolved to describe various degrees of parenchymal involvement with pyelonephritis. The Society of Uroradiology [5] has recommended that all patients with renal infection be referred to as having acute pyelonephritis, with only the additional modifiers unilateral or bilateral, focal or diffuse, focal swelling or no focal swelling, and renal enlargement or no enlargement used to describe the extent of the process.

Intravenous Urography

In the past, intravenous urography (IVU) was the primary diagnostic modality for imaging patients with renal infection. Its role has diminished, and now it plays, at best, a minor role in patients with acute pyelonephritis [6].

¹Principal Author, Northwestern University, Chicago, Illinois. ²Panel Chair, Northwestern University, Chicago, Illinois. ³Panel Vice-chair, Cleveland Clinic, Cleveland, Ohio. ⁴Intermountain Urological Institute, Murray, Utah, American Urological Association. ⁵Emory University Hospital, Atlanta, Georgia. ⁶University of Washington Medical Center, Seattle, Washington. ⁷University of New Mexico, Albuquerque, New Mexico. ⁸University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania, American Society of Nephrology. ⁹Scottsdale Medical Imaging, Scottsdale, Arizona. ¹⁰Alpert Medical School of Brown University, Providence, Rhode Island. ¹¹Wake Forest University School of Medicine, Winston Salem, North Carolina. ¹²University of Alabama at Birmingham, Birmingham, Alabama. ¹³Children's National Medical Center, Washington, District of Columbia, Society of Nuclear Medicine. ¹⁴The University of Chicago, Chicago, Illinois. ¹⁵Virginia Mason Medical Center, Seattle, Washington, American Urological Association. ¹⁶University of Pennsylvania Hospital, Philadelphia, Pennsylvania. ¹⁷Johns Hopkins Hospital, Baltimore, Maryland. ¹⁸University of Texas MD Anderson Cancer Center, Houston, Texas.

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Reprint requests to: Department of Quality & Safety, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191-4397.

The rationale for performing urography was not to diagnose acute pyelonephritis but to look for an underlying anatomic abnormality (such as a congenital anomaly) predisposing the patient to the infection, to search for an underlying process that may have prevented a rapid therapeutic response (eg, calculus, papillary necrosis, or obstruction), or to diagnose a complication of the infection such as a renal or perinephric abscess. As such, many clinicians routinely ordered an IVU or, now with increasing frequency, computed tomography (CT) of the abdomen and pelvis in all patients with a clinical diagnosis of pyelonephritis within the first 24 hours after initiation of therapy [7].

It has been demonstrated that routine urography does not alter the clinical care in 90% of patients with pyelonephritis [8]. This same study showed, however, that if investigation was confined to those patients who remained febrile after 72 hours of appropriate antibiotic therapy, the number of patients with urography findings of immediate clinical significance rose to 36%. The authors also found a five-fold increase in yield from routine urography in patients with underlying diabetes or those infected with a pathogen other than ampicillin-sensitive *Escherichia coli*.

Computed Tomography

Soulen et al [9] confirmed the validity of waiting for 72 hours prior to obtaining imaging in a study of the utility 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.

There is almost universal agreement that precontrast and postcontrast CT is the imaging study of choice to diagnose patients with atypical pyelonephritis or to look for a potential complication such as a renal or perinephric abscess or emphysematous pyelonephritis [2,9-16]. It is a widely available and a sensitive method for evaluating the complications of UTIs, and it also provides a global assessment of involvement within the abdomen and pelvis [16]. In addition to providing superior anatomic detail and improved sensitivity for detecting underlying congenital or acquired renal abnormalities, the use of intravenous contrast may provide additional functional information about the kidney. In most of the studies comparing CT with ultrasound (US), much of the superiority of CT lay in its ability to detect parenchymal abnormalities in patients with pyelonephritis that are generally missed by US.

Ultrasound

US has several advantages including low risk, wide availability, relatively low expense, lack of ionizing radiation, and the fact that it does not require the use of contrast material [16,17]. Color and power Doppler should be utilized to improve the sensitivity of US in patients with acute pyelonephritis [13]. However, US can miss subtle changes of mild pyelonephritis and often underestimates the severity of renal involvement or perinephric extension [6]. In a recent study of 147 patients with clinically suspected acute pyelonephritis by Yoo et al [18] CT showed significantly higher sensitivity than Doppler US.

With recent technical advances in US such as tissue harmonic imaging and the use of US contrast agents, the sensitivity of US to subtle parenchymal abnormalities in pyelonephritis has increased [19]. In a study by Mitterberger et al [20] comparing contrast-enhanced US (CEUS) using the contrast pulse-sequence technique and enhanced CT in 100 patients with acute pyelonephritis, CEUS was reported to be very accurate. The authors reported a sensitivity of 98%, a specificity of 100%, a low false negative rate of 2% and no false positives. This study, however, had several limitations: CT was used as the gold standard, parenchymal findings on CEUS were evaluated subjectively, and a single investigator performed all CEUS studies. Although a microbubble contrast agent is popular and widely used in Europe and Asia, the U.S. Food and Drug Administration has not approved it for general imaging in the United States [21]. Further work in this area will also be needed to confirm the accuracy of this new technique before more specific recommendations can be considered. Conventional gray-scale US is especially helpful in evaluating for hydronephrosis or pyonephrosis (ie, low-level echoes within the collecting system) [16], but CT may also suggest this diagnosis. The most specific test to diagnose pyonephrosis, however, is needle aspiration of the collecting system, which is generally performed as a prelude to percutaneous nephrostomy.

99m-Techetium-Dimercaptosuccinic Acid (DMSA) Renal Scintigraphy

There has been increased interest in the diagnosis of acute pyelonephritis using 99m-technetium dimercaptosuccinic acid (DMSA) renal scintigraphy in the pediatric population [22]. This is important in children since differentiating LUT infection from pyelonephritis is more difficult in the pediatric population and since it is the young who are more vulnerable to permanent renal damage from renal inflammatory disease. Studies have shown this technique to be much more sensitive for detecting pyelonephritis than US. Power Doppler US has

shown sensitivities and specificities approaching 90% in children with acute pyelonephritis [23,24]. Other recent studies propose routinely obtaining both renal US and DMSA scanning in children after their first febrile UTI [25]. Of note, a study by Sattari et al. suggests that CT is more accurate than technetium 99m DMSA renal scintigraphy in detecting involvement with acute pyelonephritis in adult patients [26].

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) and magnetic resonance urography (MRU) are felt to be 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. MRU also avoids exposure to radiation and combines excellent spatial resolution with assessment of renal function and drainage. Several studies comparing MRU to DMSA renal scan for the detection of pyelonephritis and renal scarring have shown MRU to be at least equivalent to DMSA scan [27,28]. Using only an unenhanced T1-weighted sequence, the sensitivity and specificity of MRI to detect renal scars were 77% and 87%, respectively [29].

The cortical phase of contrast-enhanced MRI is likely the best sequence to detect and differentiate pyelonephritis from cortical defects [27]. MRU can distinguish among acute pyelonephritis, renal scarring, and renal dysplasia [30]. MRU is also useful for detecting and characterizing congenital anomalies of the kidneys and genitourinary tract in the pediatric and adult population [31]. The use of diffusion weighted sequences is also promising, assisting in the differentiation between pyonephrosis and hydronephrosis, which may be particularly helpful for pregnant patients in the second and third trimesters [32]. Early studies have shown diffusion-weighted sequences to provide reproducible information regarding renal function [33]. One potential disadvantage of MRI is its inability to detect smaller calculi, especially when the stones are not surrounded by urine [31].

Other Imaging Studies

Abdominal radiographs (ie, abdomen and pelvis [KUB]) are of very limited use in the setting of acute pyelonephritis, unless large coexisting staghorn or obstructing calculi are being followed. Retrograde pyelography is of value in patients with severe infection and obstruction that cannot be demonstrated noninvasively. Antegrade pyelography can be used as an alternative to the retrograde study. Voiding cystourethrography is used to demonstrate vesicoureteral reflux, but it is generally only performed routinely in children.

Summary

- Otherwise healthy patients with uncomplicated pyelonephritis will typically need no radiologic workup if they respond to antibiotic therapy within 72 hours.
- If there is no response to therapy, CT of the abdomen and pelvis is the study of choice.
- Diabetics or other immunocompromised patients should be evaluated with precontrast and postcontrast CT within 24 hours of diagnosis, if response to therapy is not prompt.
- US should be reserved for patients in whom pyonephrosis is suspected and those patients for whom exposure to contrast or radiation is hazardous.
- All other complicated adult patients (eg, patients with a history of stones or other urologic conditions, prior urologic surgery, repeated episodes of pyelonephritis) probably deserve early evaluation with CT.
- For patients in whom contrast-enhanced CT is contraindicated, MRI could be considered as an alternative to CT.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m²), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m². For more information, please see the [ACR Manual on Contrast Media](#) [34].

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.

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	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

- [ACR Appropriateness Criteria® Overview](#)
- [Procedure Information](#)
- [Evidence Table](#)

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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.