

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

**Clinical Condition:** Acute Pyelonephritis

**Variant 1:** Uncomplicated patient.

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL*</u></b>
X-ray intravenous urography	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	Med
X-ray voiding cystourethrography	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	Low
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.	High
Tc-99m DMSA scan kidney	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	Med
X-ray abdomen (KUB)	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	Low
US kidneys and bladder retroperitoneal	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	None
X-ray antegrade pyelography	1	Studies show that imaging adds little to management if the patient responds to therapy within 72 hours.	Med
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.	None
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.	High
<b><u>Rating Scale:</u> 1=Least appropriate, 9=Most appropriate</b>			<b>*Relative Radiation Level</b>

**Clinical Condition:****Acute Pyelonephritis****Variant 2:****Complicated patient (eg, diabetes, immunocompromised, history of stones, prior renal surgery, not responding to therapy).**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL*</u></b>
CT abdomen and pelvis without and with contrast	8		High
US kidneys and bladder retroperitoneal with KUB	6	May be used as an alternative study to above.	Low
CT abdomen and pelvis without contrast	5		High
MRI abdomen and pelvis without and with contrast	4	See statement regarding contrast in text under "Anticipated Exceptions."	None
X-ray voiding cystourethrography	3	Not part of initial evaluation but may be used subsequently to demonstrate clinically suspected reflux.	Low
Tc-99m DMSA scan kidney	3	Cannot differentiate renal parenchymal disease from perinephric process.	Med
X-ray abdomen (KUB)	2	Insufficient information by itself to guide therapy.	Low
X-ray intravenous urography	2		Med
X-ray antegrade pyelography	1	Not an initial study.	Med
<b><u>Rating Scale:</u> 1=Least appropriate, 9=Most appropriate</b>			<b>*Relative Radiation Level</b>

## ACUTE PYELONEPHRITIS

Expert Panel on Urologic Imaging: David B. Spring, MD<sup>1</sup>; Isaac R. Francis, MD<sup>2</sup>; David D. Casalino, MD<sup>3</sup>; Ronald S. Arellano, MD<sup>4</sup>; Deborah A. Baumgarten, MD, MPH<sup>5</sup>; Nancy S. Curry, MD<sup>6</sup>; Manjiri Dighe, MD<sup>7</sup>; Gary M. Israel, MD<sup>8</sup>; S. Zafar H. Jafri, MD<sup>9</sup>; Akira Kawashima, MD<sup>10</sup>; John R. Leyendecker, MD<sup>11</sup>; Nicholas Papanicolaou, MD<sup>12</sup>; Srinivasa Prasad, MD<sup>13</sup>; Parvati Ramchandani, MD<sup>14</sup>; Erick M. Remer, MD<sup>15</sup>; Sheila Sheth, MD<sup>16</sup>; Pat Fulgham, MD.<sup>17</sup>

### **Summary of Literature Review**

Urinary tract infections 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 the treatment is started late, 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. Not only are they more vulnerable to the development of a complication from acute pyelonephritis, but 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].

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 [3]. 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 [4] 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**

Traditionally, intravenous urography (IVU) has been the primary diagnostic modality for imaging patients with renal infection. The rationale for performing urography is not to diagnose acute pyelonephritis but to look for an underlying anatomic abnormality (ie, anomaly) that may have predisposed the patient to the infection; to search for a process such as a calculus, papillary necrosis, or obstruction that may prevent a rapid therapeutic response; or to diagnose a complication of the infection such as a renal or perinephric abscess. As such, many urologists routinely order an IVU or, with increasing frequency, computed tomography (CT) of the abdomen and pelvis in all patients with clinical pyelonephritis within the first 24 hours after initiation of therapy [5].

There is now reasonably good evidence that routine urography does not alter the clinical care in 90% of patients with pyelonephritis [6]. This same study showed, however, that if investigation was confined to those patients who did not become afebrile after 72 hours of appropriate antibiotics therapy, the number of patients with urographic 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*.

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The American College of Radiology seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply society endorsement of the final document.

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Soulen et al [7] confirmed the validity of the 72-hour period 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.

### Computed Tomography and Ultrasound

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 of the infection such as a renal or perinephric abscess or a renal emphysema [2,7-15]. 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 but do not alter the patient's therapy. Soulen et al [7], however, reported that US missed six of 10 intrarenal and one of five perinephric abscesses subsequently diagnosed by CT. In only three of these cases, however, were the results verified by surgery. The proponents of US are quick to point out its advantages—namely, low risk, relatively low expense, lack of ionizing radiation, and, most importantly, the fact that it does not require the use of contrast material [16]. Recent technical advances in US such as tissue harmonic imaging and the use of US contrast agents have been shown to increase the sensitivity of US to subtle parenchymal abnormalities in pyelonephritis, but further work in this area is needed before definite recommendations can be made [17]. Conventional gray-scale US has been considered the method of choice to diagnose pyonephrosis (ie, low-level echoes within the collecting system), but CT can also suggest this diagnosis. The most specific test to diagnose pyelonephrosis, however, is needle aspiration of the collecting system, which is generally performed as a prelude to percutaneous nephrostomy.

### Other Imaging Studies

Recently there has been increased interest in the diagnosis of acute pyelonephritis using technetium 99m DMSA renal scintigraphy, particularly in children [18]. Recent studies have shown this technique to be much more sensitive for detecting pyelonephritis than US. Recently, power Doppler US has shown sensitivities and specificities approaching 90% in children with acute pyelonephritis [19,20]. 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. One recent study, however, suggests that CT is more accurate than technetium 99m DMSA renal scintigraphy in detecting acute pyelonephritis lesions in adults [21].

Various other imaging studies are of value in selected patients. Magnetic resonance imaging (MRI) is felt to be useful in patients in whom the use of iodinated contrast material must be avoided, (ie, those with azotemia or contrast sensitivity), but case-controlled studies documenting its efficacy have yet to be published. While gadolinium-based contrast agents enhanced inversion

recovery MRI has been shown to be only slightly less sensitive and specific than DMSA scintigraphy for acute pyelonephritis in children [22]. One potential disadvantage of MRI is its inability to detect smaller calculi. 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 probably 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 probably be evaluated with precontrast and postcontrast CT within 24 hours of diagnosis, if response 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.

### 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/1.73m<sup>2</sup>), 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/1.73m<sup>2</sup>. For more information, please see the [ACR Manual on Contrast Media](#) [23].

### 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. 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	Effective Dose Estimate Range
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

### Supporting Document(s)

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

### References

1. Foxman B. Epidemiology of urinary tract infections: incidence, morbidity, and economic costs. *Am J Med* 2002; 113 Suppl 1A:5S-13S.
2. June CH, Browning MD, Smith LP, et al. Ultrasonography and computed tomography in severe urinary tract infection. *Arch Intern Med* 1985; 145(5):841-845.
3. Davidson AJ, Talner LB. Urographic and angiographic abnormalities in adult-onset acute bacterial nephritis. *Radiology* 1973; 106(2):249-256.
4. Talner LB, Davidson AJ, Lebowitz RL, Dalla Palma L, Goldman SM. Acute pyelonephritis: can we agree on terminology? *Radiology* 1994; 192(2):297-305.
5. Kawashima A, LeRoy AJ. Radiologic evaluation of patients with renal infections. *Infect Dis Clin North Am* 2003; 17(2):433-456.
6. Kanel KT, Kroboth FJ, Schwentker FN, Lecky JW. The intravenous pyelogram in acute pyelonephritis. *Arch Intern Med* 1988; 148(10):2144-2148.
7. Soulen MC, Fishman EK, Goldman SM, Gatewood OM. Bacterial renal infection: role of CT. *Radiology* 1989; 171(3):703-707.
8. Benson M, Li Puma JP, Resnick MI. The role of imaging studies in urinary tract infection. *Urol Clin North Am* 1986; 13(4):605-625.
9. Bova JG, Potter JL, Arevalos E, Hopens T, Goldstein HM, Radwin HM. Renal and perirenal infection: the role of computerized tomography. *J Urol* 1985; 133(3):375-378.
10. Dalla-Palma L, Pozzi-Mucelli F, Pozzi-Mucelli RS. Delayed CT findings in acute renal infection. *Clin Radiol* 1995; 50(6):364-370.
11. Kawashima A, Sandler CM, Ernst RD, Goldman SM, Raval B, Fishman EK. Renal inflammatory disease: the current role of CT. *Crit Rev Diagn Imaging* 1997; 38(5):369-415.
12. Kawashima A, Sandler CM, Goldman SM. Imaging in acute renal infection. *BJU Int* 2000; 86 Suppl 1:70-79.
13. Kawashima A, Sandler CM, Goldman SM, Raval BK, Fishman EK. CT of renal inflammatory disease. *Radiographics* 1997; 17(4):851-866; discussion 867-858.
14. Wan YL, Lee TY, Bullard MJ, Tsai CC. Acute gas-producing bacterial renal infection: correlation between imaging findings and clinical outcome. *Radiology* 1996; 198(2):433-438.
15. Zaontz MR, Pahira JJ, Wolfman M, Gargurevich AJ, Zeman RK. Acute focal bacterial nephritis: a systematic approach to diagnosis and treatment. *J Urol* 1985; 133(5):752-757.
16. Piccirillo M, Rigsby CM, Rosenfield AT. Sonography of renal inflammatory disease. *Urol Radiol* 1987; 9(2):66-78.
17. Kim B, Lim HK, Choi MH, et al. Detection of parenchymal abnormalities in acute pyelonephritis by pulse inversion harmonic imaging with or without microbubble ultrasonographic contrast agent: correlation with computed tomography. *J Ultrasound Med* 2001; 20(1):5-14.
18. Kass EJ, Fink-Bennett D, Cacciarelli AA, Balon H, Pavlock S. The sensitivity of renal scintigraphy and sonography in detecting nonobstructive acute pyelonephritis. *J Urol* 1992; 148(2 Pt 2):606-608.
19. Bykov S, Chervinsky L, Smolkin V, Halevi R, Garty I. Power Doppler sonography versus Tc-99m DMSA scintigraphy for diagnosing acute pyelonephritis in children: are these two methods comparable? *Clin Nucl Med* 2003; 28(3):198-203.
20. Halevy R, Smolkin V, Bykov S, Chervinsky L, Sakran W, Koren A. Power Doppler ultrasonography in the diagnosis of acute childhood pyelonephritis. *Pediatr Nephrol* 2004; 19(9):987-991.
21. Sattari A, Kampouridis S, Damry N, et al. CT and 99mTc-DMSA scintigraphy in adult acute pyelonephritis: a comparative study. *J Comput Assist Tomogr* 2000; 24(4):600-604.
22. Kovanlikaya A, Okkay N, Cakmakci H, Ozdogan O, Degirmenci B, Kavukcu S. Comparison of MRI and renal cortical scintigraphy findings in childhood acute pyelonephritis: preliminary experience. *Eur J Radiol* 2004; 49(1):76-80.
23. American College of Radiology. *Manual on Contrast Media*. Available at: [http://www.acr.org/SecondaryMainMenuCategories/quality\\_safety/contrast\\_manual.aspx](http://www.acr.org/SecondaryMainMenuCategories/quality_safety/contrast_manual.aspx).

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.