American College of Radiology
ACR Appropriateness Criteria®

Recurrent Lower Urinary Tract Infections in Females

Variant: 1 Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.

Procedure	Appropriateness Category	Relative Radiation Level
US kidneys and bladder retroperitoneal	Usually Not Appropriate	O
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢☢
Radiography abdomen	Usually Not Appropriate	☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢
Fluoroscopy cystography	Usually Not Appropriate	☢☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT pelvis with bladder contrast (CT cystography)	Usually Not Appropriate	☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 2 Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.

Procedure	Appropriateness Category	Relative Radiation Level
MRU without and with IV contrast	Usually Appropriate	O
CTU without and with IV contrast	Usually Appropriate	☢☢☢☢
US kidneys and bladder retroperitoneal	May Be Appropriate	O
Fluoroscopy voiding cystourethrography	May Be Appropriate	☢☢
Fluoroscopy cystography	May Be Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	O
MRI abdomen and pelvis without IV contrast	May Be Appropriate	O
CT abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
CT pelvis with bladder contrast (CT cystography)	May Be Appropriate	☢☢☢☢
Fluoroscopy urethrography double balloon	Usually Not Appropriate	☢☢
Radiography abdomen	Usually Not Appropriate	☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢☢

Panel Members

Aradhana M. Venkatesan, MD[a], Aytekin Oto, MD[b], Brian C. Allen, MD[c], Oguz Akin, MD[d], Lauren F. Alexander, MD[e], Jaron Chong, MD[f], Adam T. Froemming, MD[g], Pat F. Fulgham, MD[h], Stanley Goldfarb, MD[i], Lori Mankowski Gettle, MD, MBA[j], Jodi K. Maranchie, MD[k], Bhavik N. Patel, MD, MBA[l], Nicola Schieda, MD[m], David M. Schuster, MD[n], Baris Turkbey, MD[o], Mark E. Lockhart, MD, MPH[p]

Summary of Literature Review

Introduction/Background

A urinary tract infection (UTI) is an infection of the urinary system causing an inflammatory response. A UTI occurs when the normal flora of the periurethral area are replaced by uropathogenic bacteria, which ascend, causing bacterial cystitis. Less commonly, this infection ascends to the kidney to cause bacterial pyelonephritis [1]. The overall lifetime risk of UTI for women is >50% [2].

An uncomplicated UTI is classified as a UTI without structural or functional abnormalities of the urinary tract and without relevant comorbidities. It should be noted that although uncomplicated UTI includes both lower tract infection (cystitis) and upper tract infection (pyelonephritis), repeated pyelonephritis should prompt consideration of a complicated etiology [1]. Complicated UTIs are those occurring in patients with underlying structural or medical problems [3,4]. Anatomical abnormalities include cystoceles, bladder or urethral diverticula, fistulae, indwelling catheters, urinary tract obstruction and underlying conditions such as voiding dysfunction, pregnancy, diabetes, and immunosuppression. Other documented risk factors include prior urinary tract surgery or trauma, gross hematuria after infection resolution, urea-splitting bacteria on culture, prior abdominopelvic malignancy, prior urinary tract calculi, prior diverticulitis, symptoms of pneumaturia, fecaluria, or repeated pyelonephritis.

In the nonobstructed, nonpregnant woman, uncomplicated UTI is usually treated empirically and responds to appropriate antimicrobial therapy [2,5]. A UTI is considered recurrent when it follows the complete clinical resolution of a previous UTI [6]. Recurrent lower UTIs are usually defined as at least three episodes of infection within the preceding 12 months [3]. Recurrent UTIs involve reinfection from a source outside of the urinary tract or from bacterial persistence [1-3]. In most cases, such infections are the result of sexual habits and hygiene (eg, women who are sexually active, especially those using diaphragms and/or spermatocides) [3,7]. Although antibiotic prophylaxis effectively limits UTI recurrence, it increases the risk of antibiotic resistance for both the causative microorganisms and the indigenous flora and risks adverse effects. It therefore should be approached judiciously. Before considering antibiotic prophylaxis for recurrent UTIs, self-care measures should be advised, including ensuring adequate hydration to promote more frequent urination, encouraging urge-initiated voiding and post-coital voiding, the avoidance of spermicidal-containing contraceptives, and, for postmenopausal women with risk factors such as atrophic vaginitis, the prescription of topical vaginal estrogens, as appropriate [8,9]. A clean-catch or catheterized specimen for culture typically reveals >100,000 organisms per milliliter of urine. E. coli is the most common organism in all patient groups, causing approximately 75% of recurrent UTIs, with most other infections caused by E. faecalis, Proteus mirabilis, Klebsiella, or S. saprophyticus particularly in patients with risk factors for complicated UTIs [6,10-12]. Postmenopausal women are at increased risk for recurrent UTI in the presence of urinary incontinence, cystocele, or high postvoid residuals of urine [13,14].

Women who have three or more symptomatic infections over a 12-month period may benefit from prophylaxis [3,4,7]. Imaging is of low yield in patients without underlying risk factors, less than two episodes per year on average, and who respond promptly to appropriate therapy (see Appendix 1) [1,7,15,16]. Current clinical guidelines indicate that imaging should not be routinely obtained in the index patient presenting with recurrent UTIs because of the low yield of anatomic abnormalities [17]. Recurrent and chronic infections with the same organism are termed "relapses" or "persistent" infections. If infection develops more than 2 weeks after a symptomatic cure, or if it is caused by a second pathogen, it is termed a "reinfection" [7].

Conversely, those patients with bacterial cystitis who recur rapidly (eg, within 2 weeks of initial treatment) after symptom resolution or who display bacterial persistence without symptom resolution may be reclassified as complicated and may require imaging [17]). Causes of bacterial persistence include calculi, foreign bodies, urethral or bladder diverticula, infected urachal cyst, and postoperative changes such as a remaining urethral stump that retains urine and results in stasis. In such patients, imaging is indicated to detect a treatable condition and monitor its progress. As described in the ACR Appropriateness Criteria® topic on "Acute Pyelonephritis" [18], there can be difficulty in differentiating a lower UTI from one with renal parenchymal involvement. In such situations, imaging studies are used for diagnosis and treatment planning.

Special Imaging Considerations

CTU

CT urography (CTU) is an imaging study that is tailored to improve visualization of both the upper and lower urinary tracts. There is variability in the specific parameters, but it usually involves unenhanced images followed by intravenous (IV) contrast-enhanced images, including nephrographic and excretory phases acquired at least 5 minutes after contrast injection. Alternatively, a split-bolus technique uses an initial loading dose of IV contrast and then obtains a combined nephrographic-excretory phase after a second IV contrast dose; some sites include arterial phase. CTU should use thin-slice acquisition. Reconstruction methods commonly include maximum intensity projection or 3-D volume rendering. For the purposes of this document, we make a distinction between CTU and CT abdomen and pelvis without and with IV contrast. CT abdomen and pelvis without and with IV contrast is defined as any protocol not specifically tailored for evaluation of the upper and lower urinary tracts and without both the precontrast and excretory phases, as is the case for CTU.

CT Pelvis with Bladder Contrast (CT Cystography)

CT cystography is an imaging study that is tailored to visualize traumatic bladder lesions. This technique involves retrograde drip infusion of diluted iodinated contrast into the urinary bladder followed by pelvic CT imaging at maximal bladder distension. IV contrast may be administered, particularly if evaluating for underlying neoplastic or inflammatory processes [19].

For the purposes of this document, we distinguish CT cystography from CT abdomen and pelvis without and with IV contrast. CT abdomen and pelvis without and with IV contrast is also defined as any protocol not specifically tailored for evaluation of the integrity of the urinary bladder wall and without retrograde instillation of contrast into the urinary bladder, as is the case for CT cystography.

MRU

MR urography (MRU) is also tailored to improve imaging of the urinary system. Unenhanced MRU relies upon heavily T2-weighted imaging of the intrinsic high signal intensity from urine for evaluation of the urinary tract. IV contrast is administered to provide additional information regarding obstruction, urothelial thickening, focal lesions, and stones. A contrast-enhanced T1-weighted series should include corticomedullary, nephrographic, and excretory phase. Thin-slice acquisition and multiplanar imaging should be obtained. For the purposes of this document, we make a distinction between MRU and MRI abdomen and pelvis without and with IV contrast. MRI abdomen and pelvis without and with IV contrast is defined as any protocol not specifically tailored for evaluation of the upper and lower urinary tracts, without both the precontrast and excretory phases and without heavily T2-weighted images of the urinary tract, as is the case for MRU.

US Abdomen with IV Contrast

Prior studies show promise regarding the potential role of contrast-enhanced ultrasound (US) for the initial diagnosis and follow-up of patients with complicated acute pyelonephritis [20-22]. Using CT as a reference standard, Mitterberger et al [22] demonstrated a sensitivity of 98% and a specificity of 100% for contrast-enhanced US in the diagnosis of acute pyelonephritis in 100 patients. Its use in current mainstream practice remains limited, however, with only recent FDA approval for abdominal imaging applications.

Discussion of Procedures by Variant

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.

In women with recurrent uncomplicated UTIs, cystoscopy and imaging are not routinely used [1]. Lawrentschuk et al [23] showed that women with no risk factors for UTI had a negative predictive value of 93% for normal cystoscopy. Prior series have demonstrated a low yield of nonincidental findings in those patients with a low pretest probability of complicated UTI [1,24].

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.
A. CT abdomen and pelvis

There are no specific guidelines recommending imaging studies in women who have recurrent UTIs but no known underlying medical or anatomic conditions [6,25]. As such, CT is not generally performed for evaluation of uncomplicated UTI.

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.
B. CT Pelvis with Bladder Contrast (CT Cystography)

There are no specific guidelines recommending imaging studies in women who have recurrent UTIs but no known underlying medical or anatomic conditions [6,20]. As such, CT cystography is not generally performed for evaluation of uncomplicated UTI.

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.
C. CTU

There are no specific guidelines recommending imaging studies in women who have recurrent UTIs but no known underlying medical or anatomic conditions [6,20]. As such, CTU is not generally performed for evaluation of uncomplicated UTI.

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.
D. Fluoroscopy Contrast Enema

Although fluoroscopic contrast enema may be useful in the setting of suspected vesicoenteric fistula, it is not used for imaging in women with recurrent uncomplicated UTIs in the absence of risk factors.

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.
E. Fluoroscopy Cystography

A prior prospective study of findings with excretory urography, cystography, and cystoscopy in women with symptomatic UTI revealed only rare instances of abnormalities important in the treatment of UTI in this group of patients, primarily urethral diverticula [26]. Most women with recurrent uncomplicated UTIs in the absence of risk factors have normal urinary tracts and do not routinely require imaging with fluoroscopic cystography.

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.
F. Fluoroscopy Voiding Cystourethrography

As most women with recurrent uncomplicated UTIs in the absence of risk factors have normal urinary tracts, they do not routinely require imaging with voiding cystourethrography. A prior prospective study including findings of excretory urography in women with symptomatic UTI revealed only rare instances of structural abnormalities important in the treatment of UTI in this group of patients [26].

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.
G. MRI Abdomen and Pelvis

CT and MRU have supplanted the use of IV urography (IVU) at most institutions for most types of urinary applications [27]. However, most women with recurrent uncomplicated UTIs in the absence of risk factors have normal urinary tracts and do not routinely require imaging with MRI.

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.
H. MRU

CT and MRU have supplanted the use of IVU at most institutions for most types of urinary applications [27]. However, most women with recurrent uncomplicated UTIs in the absence of risk factors have normal urinary tracts and do not routinely require imaging with MRI.

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.
I. Radiography Abdomen

As most women with recurrent symptomatic UTI have normal urinary tracts, they do not routinely require imaging with radiography of the abdomen.

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no

underlying risk factors.
J. Radiography Intravenous Urography

Historically, intravenous urography (IVU) was the imaging study of choice to evaluate the urinary tract, but it is no longer used at most institutions [13]. IVU is not used for evaluation of uncomplicated UTI.

Variant 1: Recurrent lower urinary tract infections in a female. Uncomplicated with no underlying risk factors.
K. US Kidneys and Bladder Retroperitoneal

As most women with recurrent symptomatic UTI have normal urinary tracts, they do not routinely require imaging with US of the kidneys, bladder, and retroperitoneum.

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.

Complicated causes of UTI can be evaluated by history and physical examination. In women suspected of having a recurrent complicated UTI, cystoscopy and imaging should be considered [24].

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.
A. CT Abdomen and Pelvis

Historically, unenhanced CT has been used predominantly for the emergency patient with renal colic and/or hematuria. It has also been used to define the severity and extent of upper tract calculi, which are occasionally associated with recurrent complicated UTIs. The lack of additional contrast-enhanced CT imaging and the lack of dedicated imaging of the collecting systems, kidneys, and bladder limits further evaluation of underlying anatomical or pathophysiologic processes.

Contrast-enhanced CT has been used effectively to evaluate a range of urinary tract abnormalities, including renal masses, genitourinary trauma, and specific aspects of renal infection, including the presence of pyelonephritis, renal abscesses, and obstruction. However, a contrast-enhanced CT of the abdomen and pelvis remains a study that is not tailored for evaluation of the urothelium and therefore does not optimally evaluate the collecting systems, ureters, and bladder. Moreover, lacking an unenhanced CT component, a contrast-enhanced CT of the abdomen and pelvis can limit the detection of calculi and the characterization of enhancement within masses [24]. The addition of rectal contrast or oral contrast with delayed scanning of an enhanced CT of the abdomen and pelvis is useful to detect enterovesical fistulas and infected fistulous tracts [28].

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.
B. CT Pelvis with Bladder Contrast (CT Cystography)

CT cystography has supplanted fluoroscopic cystogram for the evaluation of traumatic bladder injuries, including intraperitoneal, extraperitoneal, or combined rupture and bladder contusions [29]. It is also useful for diagnosing bladder fistulas and leaks, particularly colovesical fistulas occurring as a result of sigmoid diverticular disease, which can remain undiagnosed despite evaluation with cystoscopy and contrast-enhanced CT [19].

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.
C. CTU

CTU is a primary test for the evaluation of recurrent complicated UTIs. It includes unenhanced, nephrographic phase, and excretory phase images, with the latter providing a detailed anatomic depiction of each of the major portions of the urinary tract including the kidneys, intrarenal collecting systems, ureters, and bladder [30]. Diuretic administration prior to the excretory phase can augment both urinary tract distention and opacification [30]. CTU has excellent sensitivity and specificity for the identification of renal and urothelial lesions [31]. This allows patients with hematuria to be evaluated comprehensively and can identify abnormalities of the collecting systems [27]. It is also useful for detecting or excluding congenital anomalies or obstruction of the urinary tract in patients with complicated recurrent UTIs. Given the low yield of CTU screening for asymptomatic hematuria in patients <30 years of age, or without risk factors for urinary tract malignancy, US or noncontrast CT may be the first-line imaging examinations in these patients. When there are risk factors present for urinary tract malignancy and the patient is >50 years of age, CTU is the preferred examination [31].

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.
D. Fluoroscopy Contrast Enema

Contrast enema is generally not useful for women with recurrent complicated UTIs. Although it may be utilized for imaging of vesicoenteric fistulas, CT is the primary imaging modality for suspected cases of enterovesical fistulas and has been found to have a higher rate of detection and also capable of identifying the underlying etiology [32,33]. If an enema is performed, water-soluble contrast should be selected rather than barium.

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.
E. Fluoroscopy Cystography

Fluoroscopic cystography is generally not useful for women with recurrent complicated UTIs. Although it can delineate bladder diverticuli and vesicoenteric fistulas, CT has supplanted fluoroscopic cystography at most institutions.

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.
F. Fluoroscopy Urethrography Double Balloon

Double-balloon urethrography can be useful for demonstration of urethral diverticula, although MRI best assesses the structure and complexity of urethral diverticula, allowing for accurate diagnosis and improved surgical planning. MRI to evaluate for urethral diverticulum has replaced double-balloon urethrography at most institutions. Double-balloon urethrography can be technically difficult and may be uncomfortable for the patient. For this document, it is assumed the procedure is performed and interpreted by an expert.

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.

G. Fluoroscopy Voiding Cystourethrography

When a bladder diverticulum is at or near a ureteral orifice, voiding cystourethrography can be considered to evaluate the possibility of vesicoureteral reflux [34]. It can also be employed for imaging of suspected bladder or urethral fistula, urethral diverticulum, or bladder prolapse.

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.

H. MRI Abdomen and Pelvis

Both MRI of the abdomen and pelvis and MRU can be used to evaluate the urinary tract and have the advantage to provide more functional information than CT. MRI has been shown to be useful in the diagnosis and follow-up of UTI and acute pyelonephritis [27,35,36]. MRI is effective at diagnosing pelvic-organ prolapse. The resultant cystoceles and urinary incontinence associated with pelvic-organ prolapse are significant risk factors for recurrent UTIs in postmenopausal women [13,37,38].

MRI is the optimum imaging modality for assessment of the structure and complexity of urethral diverticula, allowing for accurate diagnosis and improved surgical planning [39]. Given the excellent soft-tissue contrast on MRI, this modality is equally sensitive to CT for evaluating vesicovaginal and enterovesicular fistulae [40,41]. In at least one study, MRI altered the surgical management in 15% of patients [39].

A history of recurrent UTI is seen in 30% to 50% of patients with urethral diverticula. Diverticula of the urethra can be evaluated with high sensitivity and specificity by double-balloon urethrography, voiding CT urethrography, and MRI [42-44]. MRI best assesses the structure and complexity of urethral diverticula, allowing for accurate diagnosis and improved surgical planning. Patients with suspected bladder diverticula may be imaged with cystography, US, or CT [45]. Bladder diverticula are unusual in women and are associated with a neurogenic or postoperative bladder; they are rarely congenital. MRI has also been shown to be accurate in the diagnosis of colovesical fistula. The multiplanar imaging capability and high soft-tissue resolution inherent to MRI also makes this modality suitable for imaging suspected fistulae, particularly when repeat imaging is an issue [40,41]. IVU, US, and upper gastrointestinal or small-bowel follow-through have very low yields for fistula [46,47].

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.

I. MRU

MRU is useful to evaluate suspected urinary tract obstruction, hematuria, and congenital anomalies, as well as postoperative anatomy. The most common MRU techniques for displaying the urinary tract can be divided into two categories: static-fluid MRU and excretory MRU. Static-fluid MRU makes use of heavily T2-weighted sequences to image the urinary tract as a static collection of fluid, can be repeated sequentially (cine MRU) to better demonstrate the ureters in their entirety and to confirm the presence of fixed stenoses, and is most successful in patients with dilated or obstructed collecting systems. Excretory MRU is performed during the excretory phase of enhancement after the IV administration of gadolinium-based contrast material. Diuretic administration is integral to excretory MRU to better demonstrate nondilated systems. Static-fluid and excretory MRU can be combined with conventional MRI for comprehensive evaluation of the urinary tract [48]. MRU can be used to evaluate the urinary tract and provides more functional information than CT provides. However, MRU is less established and less reliable and thus results in lesser diagnostic image quality relative to CTU [23]. In comparison to CTU, it necessitates a longer examination time and is less sensitive than CT for detecting urinary tract calculi. In a study of 149 patients, MRU demonstrated 69% sensitivity for detecting calculi versus 100% for CT [49]. However, MRU has shown increased sensitivity for perirenal fluid and ureteric dilatation in comparison with CT in the setting of acute obstruction [50]. Multiplanar reconstruction images in the coronal and sagittal planes are commonly included in MRU images to improve visualization of urinary tract abnormalities [27,48]. Additional benefits for MRU are in documenting active upper-tract infection versus scar formation to determine whether therapy has been effective in the high-risk patient.

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.
J. Radiography Abdomen

Radiography of the abdomen has long been employed for the detection of calculi, intramural bladder wall calcification, gas in the wall or lumen of the urinary bladder, and/or foreign bodies that may be the etiology of a UTI. Use of digital tomosynthesis of the abdomen results in improved detection of urinary stones in general over digital radiography [51]. Bladder-wall calcification, when present, is typically due to prior infection with Schistosoma (uncommon in the United States, but very common in other parts of the world), tuberculosis, Cytoxan cystitis, or radiation cystitis [52]. For women with recurrent UTIs, however, abdominal radiography is generally not a useful diagnostic tool as other imaging modalities have higher sensitivity and specificity in this setting.

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.
K. Radiography Intravenous Urography

CT and MRU have supplanted the use of IVU for evaluation of urinary abnormalities at most institutions [27], and it is generally not useful for women with recurrent complicated UTIs.

Variant 2: Recurrent lower urinary tract infections in a female. Complicated, or patients who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors.
L. US Kidneys and Bladder Retroperitoneal

US may be useful in women with recurrent UTIs, particularly prior to pregnancy, to evaluate for hydronephrosis and risk factors for recurrent infection. Hydronephrosis can be demonstrated as an indication of obstruction, although US may not yield a specific etiology [53-55]. US is a useful initial screening tool for obstructive uropathy and for postvoid residual volume determination to detect incomplete bladder emptying [56]. It should be noted, although US can detect renal stones, it is generally less sensitive than CT [57-59]. Renal abscess or perinephric collections can also be detected sonographically, and US of the bladder can be employed to evaluate for bladder diverticula detection [45].

Summary of Highlights

- **Variant 1:** Imaging is usually not appropriate for recurrent uncomplicated lower UTIs in a female with no known underlying risk factors.
- **Variant 2:** In a female suspected of having a recurrent complicated UTI, cystoscopy and imaging should be considered. CTU or MRU are usually appropriate for the evaluation of recurrent complicated lower UTIs or for a female who are nonresponders to conventional therapy, develop frequent reinfections or relapses, or have known underlying risk factors. CTU and MRU are considered equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

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, because of both 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 with 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 (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

References

-2. Griebling TL. Urologic diseases in America project: trends in resource use for urinary tract infections in women. J Urol. 2005;173(4):1281-1287.

-2. Foxman B. Epidemiology of urinary tract infections: incidence, morbidity, and economic costs. Dis Mon. 2003;49(2):53-70.

-2. Wagenlehner FM, Weidner W, Naber KG. An update on uncomplicated urinary tract infections in women. Curr Opin Urol. 2009;19(4):368-374.

-2. Hickling DR, Nitti VW. Management of recurrent urinary tract infections in healthy adult women. Rev Urol. 2013;15(2):41-48.

-2. Dason S, Dason JT, Kapoor A. Guidelines for the diagnosis and management of recurrent urinary tract infection in women. Can Urol Assoc J. 2011;5(5):316-322.

-2. Sheffield JS, Cunningham FG. Urinary tract infection in women. Obstet Gynecol. 2005;106(5 Pt 1):1085-1092.

-2. Gupta K, Hooton TM, Naber KG, et al. International clinical practice guidelines for the treatment of acute uncomplicated cystitis and pyelonephritis in women: A 2010 update by the Infectious Diseases Society of America and the European Society for Microbiology and Infectious Diseases. [Review]. Clinical Infectious Diseases. 52(5):e103-20, 2011 Mar 01.

-2. Glover M, Moreira CG, Sperandio V, Zimmern P. Recurrent urinary tract infections in healthy and nonpregnant women. Urological Science. 25(1):1-8, 2014 Mar.

-2. Arnold JJ, Hehn LE, Klein DA. Common Questions About Recurrent Urinary Tract Infections in Women. [Review]. American Family Physician. 93(7):560-9, 2016 Apr 01.

-2. Beerepoot M, Geerlings S. Non-Antibiotic Prophylaxis for Urinary Tract Infections. [Review].

Pathogens. 5(2), 2016 Apr 16.

-2. Hooton TM, Vecchio M, Iroz A, et al. Effect of Increased Daily Water Intake in Premenopausal Women With Recurrent Urinary Tract Infections: A Randomized Clinical Trial. JAMA Intern Med. 178(11):1509-1515, 2018 11 01.

-1. Haylen BT, Lee J, Husselbee S, Law M, Zhou J. Recurrent urinary tract infections in women with symptoms of pelvic floor dysfunction. Int Urogynecol J Pelvic Floor Dysfunct. 2009;20(7):837-842.

0. Raz R, Gennesin Y, Wasser J, et al. Recurrent urinary tract infections in postmenopausal women. Clinical Infectious Diseases. 30(1):152-6, 2000 Jan.

1. Kodner CM, Thomas Gupton EK. Recurrent urinary tract infections in women: diagnosis and management. Am Fam Physician. 2010 Sep 15;82(6):638-43.

2. Fenwick EA, Briggs AH, Hawke CI. Management of urinary tract infection in general practice: a cost-effectiveness analysis. Br J Gen Pract. 2000;50(457):635-639.

3. van Haarst EP, van Andel G, Heldeweg EA, Schlatmann TJ, van der Horst HJ. Evaluation of the diagnostic workup in young women referred for recurrent lower urinary tract infections. Urology. 2001;57(6):1068-1072.

4. Anger J, Lee U, Ackerman AL, et al. Recurrent Uncomplicated Urinary Tract Infections in Women: AUA/CUA/SUFU Guideline. Journal of Urology. 202(2):282-289, 2019 08.

5. Nikolaidis P, Dogra VS, Goldfarb S, et al. ACR Appropriateness Criteria R Acute Pyelonephritis. Journal of the American College of Radiology. 15(11S):S232-S239, 2018 Nov.

6. Tonolini M, Bianco R. Multidetector CT cystography for imaging colovesical fistulas and iatrogenic bladder leaks. Insights Imaging. 2012 Apr;3(2):181-7.

7. Fontanilla T, Minaya J, Cortes C, et al. Acute complicated pyelonephritis: contrast-enhanced ultrasound. Abdom Imaging. 2012;37(4):639-646.

8. Granata A, Andrulli S, Fiorini F, et al. Diagnosis of acute pyelonephritis by contrast-enhanced ultrasonography in kidney transplant patients. Nephrol Dial Transplant. 2011;26(2):715-720.

9. Mitterberger M, Pinggera GM, Colleselli D, et al. Acute pyelonephritis: comparison of diagnosis with computed tomography and contrast-enhanced ultrasonography. BJU Int. 2008; 101(3):341-344.

10. Lawrentschuk N, Ooi J, Pang A, Naidu KS, Bolton DM. Cystoscopy in women with recurrent urinary tract infection. Int J Urol. 2006;13(4):350-353.

11. Hooton TM. Recurrent urinary tract infection in women. Int J Antimicrob Agents. 2001 Apr;17(4):259-68.

12. Neal DE. Complicated urinary tract infections. Urol Clin North Am. 2008 Feb;35(1):13-22; v.

13. Fowler JE, Pulaski ET. Excretory urography, cystography, and cystoscopy in the evaluation of women with urinary-tract infection: a prospective study. N Engl J Med. 1981 Feb 19;304(8):462-5.

14. Silverman SG, Leyendecker JR, Amis ES, Jr. What is the current role of CT urography and MR urography in the evaluation of the urinary tract? Radiology. 2009;250(2):309-323.

15. Khati NJ, Sondel Lewis N, Frazier AA, Obias V, Zeman RK, Hill MC. CT of acute perianal abscesses and infected fistulae: a pictorial essay. Emerg Radiol. 2015 Jun;22(3):329-35.

16. Morey AF, Brandes S, Dugi DD 3rd, et al. Urotrauma: AUA guideline. Journal of Urology. 192(2):327-35, 2014 Aug.J Urol. 192(2):327-35, 2014 Aug.

17. Dillman JR, Caoili EM, Cohan RH. Multi-detector CT urography: a one-stop renal and urinary tract imaging modality. Abdom Imaging. 2007;32(4):519-529.

18. Zeikus E, Sura G, Hindman N, Fielding JR. Tumors of Renal Collecting Systems, Renal Pelvis, and Ureters: Role of MR Imaging and MR Urography Versus Computed Tomography Urography. [Review]. Magnetic Resonance Imaging Clinics of North America. 27(1):15-32, 2019 Feb.Magn Reson Imaging Clin N Am. 27(1):15-32, 2019 Feb.

19. Kavanagh D, Neary P, Dodd JD, Sheahan KM, O'Donoghue D, Hyland JM. Diagnosis and treatment of enterovesical fistulae. Colorectal Dis. 2005;7(3):286-291.

20. Yu NC, Raman SS, Patel M, Barbaric Z. Fistulas of the genitourinary tract: a radiologic review. [Review] [75 refs]. Radiographics. 24(5):1331-52, 2004 Sep-Oct.

21. Amar AD, Das S. Vesicoureteral reflux in women with primary bladder diverticulum. J Urol. 1985;134(1):33-35.

22. Majd M, Nussbaum Blask AR, Markle BM, et al. Acute pyelonephritis: comparison of diagnosis with 99mTc-DMSA, SPECT, spiral CT, MR imaging, and power Doppler US in an experimental pig model. Radiology. 2001; 218(1):101-108.

23. Martina MC, Campanino PP, Caraffo F, et al. Dynamic magnetic resonance imaging in acute pyelonephritis. Radiol Med. 2010;115(2):287-300.

24. Boyadzhyan L, Raman SS, Raz S. Role of static and dynamic MR imaging in surgical pelvic floor dysfunction. Radiographics. 2008;28(4):949-967.

25. Woodfield CA, Krishnamoorthy S, Hampton BS, Brody JM. Imaging pelvic floor disorders: trend toward comprehensive MRI. AJR Am J Roentgenol. 2010;194(6):1640-1649.

26. Foster RT, Amundsen CL, Webster GD. The utility of magnetic resonance imaging for diagnosis and surgical planning before transvaginal periurethral diverticulectomy in women. Int Urogynecol J Pelvic Floor Dysfunct. 2007; 18(3):315-319.

27. Ravichandran S, Ahmed HU, Matanhelia SS, Dobson M. Is there a role for magnetic resonance imaging in diagnosing colovesical fistulas?. Urology. 72(4):832-7, 2008 Oct.Urology. 72(4):832-7, 2008 Oct.

28. Tang YZ, Booth TC, Swallow D, et al. Imaging features of colovesical fistulae on MRI. Br J Radiol. 2012;85(1018):1371-1375.

29. Chang YL, Lin AT, Chen KK. Presentation of female urethral diverticulum is usually not typical. Urol Int. 80(1):41-5, 2008.

30. Chou CP, Huang JS, Wu MT, et al. CT voiding urethrography and virtual urethroscopy: preliminary study with 16-MDCT. AJR Am J Roentgenol. 2005 Jun;184(6):1882-8.

31. Chou CP, Levenson RB, Elsayes KM, et al. Imaging of female urethral diverticulum: an update. [Review] [40 refs]. Radiographics. 28(7):1917-30, 2008 Nov-Dec.

32. Caoili EM, Cohan RH, Korobkin M, et al. Urinary tract abnormalities: initial experience with multi-detector row CT urography. Radiology. 2002 Feb;222(2):353-60.

33. Goldman SM, Fishman EK, Gatewood OM, Jones B, Siegelman SS. CT in the diagnosis of enterovesical fistulae. AJR Am J Roentgenol. 1985;144(6):1229-1233.

34. Najjar SF, Jamal MK, Savas JF, Miller TA. The spectrum of colovesical fistula and diagnostic paradigm. Am J Surg. 188(5):617-21, 2004 Nov.

35. Leyendecker JR, Barnes CE, Zagoria RJ. MR urography: techniques and clinical applications. Radiographics. 2008; 28(1):23-46; discussion 46-27.

36. Shokeir AA, El-Diasty T, Eassa W, et al. Diagnosis of ureteral obstruction in patients with compromised renal function: the role of noninvasive imaging modalities. J Urol. 2004;171(6 Pt 1):2303-2306.

37. Regan F, Kuszyk B, Bohlman ME, Jackman S. Acute ureteric calculus obstruction: unenhanced spiral CT versus HASTE MR urography and abdominal radiograph. Br J Radiol. 2005;78(930):506-511.

38. Mermuys K, De Geeter F, Bacher K, et al. Digital tomosynthesis in the detection of urolithiasis: Diagnostic performance and dosimetry compared with digital radiography with MDCT as the reference standard. AJR Am J Roentgenol. 2010;195(1):161-167.

39. Pollack HM, Banner MP, Martinez LO, Hodson CJ. Diagnostic considerations in urinary bladder wall calcification. AJR Am J Roentgenol. 1981;136(4):791-797.

40. Amis ES, Jr., Cronan JJ, Pfister RC, Yoder IC. Ultrasonic inaccuracies in diagnosing renal obstruction. Urology. 1982;19(1):101-105.

41. Denton T, Cochlin DL, Evans C. The value of ultrasound in previously undiagnosed renal failure. Br J Radiol. 1984;57(680):673-675.

42. Kamholtz RG, Cronan JJ, Dorfman GS. Obstruction and the minimally dilated renal collecting system: US evaluation. Radiology. 1989;170(1 Pt 1):51-53.

43. Choe JH, Lee JY, Lee KS. Accuracy and precision of a new portable ultrasound scanner, the BME-150A, in residual urine volume measurement: a comparison with the BladderScan BVI 3000. Int Urogynecol J Pelvic Floor Dysfunct. 2007;18(6):641-644.

44. Ray AA, Ghiculete D, Pace KT, Honey RJ. Limitations to ultrasound in the detection and measurement of urinary tract calculi. Urology. 2010;76(2):295-300.

45. Sheafor DH, Hertzberg BS, Freed KS, et al. Nonenhanced helical CT and US in the emergency evaluation of patients with renal colic: prospective comparison. Radiology. 2000;217(3):792-797.

46. Viprakasit DP, Sawyer MD, Herrell SD, Miller NL. Limitations of ultrasonography in the evaluation of urolithiasis: a correlation with computed tomography. J Endourol. 2012;26(3):209-213.

47. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: https://edge.sitecorecloud.io/americancoldf5f-acrorgf92a-productioncb02-3650/media/ACR/Files/Clinical/Appropriateness-Criteria/ACR-Appropriateness-Criteria-Radiation-Dose-Assessment-Introduction.pdf.

49. Committee Opinion No. 723: Guidelines for Diagnostic Imaging During Pregnancy and Lactation. Obstet Gynecol. 2017 Oct;130(4):e210-e216.

51. ACOG Practice Bulletin No. 101: Ultrasonography in pregnancy. Obstet Gynecol. 2009 Feb;113(2 Pt 1):451-61.

53. Chahine R, Mendiratta-Lala M, Consul N, et al. What can go wrong when doing right? A pictorial review of iatrogenic genitourinary complications. Abdom Radiol (NY). 2024 Nov;49(11):3987-4002.

55. Chulroek T, Wangcharoenrung D, Cattapan K, et al. Can magnetic resonance imaging differentiate among transurethral bulking agent, urethral diverticulum, and periurethral cyst?. Abdom Radiol (NY). 2019 Aug;44(8):2852-2863.

57. Cruz J, Figueiredo F, Matos AP, Duarte S, Guerra A, Ramalho M. Infectious and Inflammatory Diseases of the Urinary Tract: Role of MR Imaging. Magn Reson Imaging Clin N Am. 2019 Feb;27(1):S1064-9689(18)30068-0.

59. De Cecco CN, Boll DT, Bolus DN, et al. White Paper of the Society of Computed Body Tomography and Magnetic Resonance on Dual-Energy CT, Part 4: Abdominal and Pelvic Applications. J Comput Assist Tomogr. 2017 Jan;41(1):8-14.

61. Fananapazir G, Golshani B, Chen LX, McGahan JP, de Mattos AM, Corwin MT. Bladder debris on ultrasound in the emergency department: correlation with urinalysis. Abdom Radiol (NY). 2018 Sep;43(9):2462-2466.

63. Kimura K, Yamamoto T, Tsuchiya J, et al. A diagnostic approach of various urethral diseases using multimodal imaging findings: comprehensive overview. Abdom Radiol (NY). 2024 Dec;49(12):4416-4436.

65. Lopes KR, Jorge BM, Barbosa MH, Barichello E, Nicolussi AC. Use of ultrasonography in the evaluation of urinary retention in critically ill patients. Rev Lat Am Enfermagem. 2023;31():e4026.

67. Mahfouz W, Hassan HHM, Gubbiotti M, Elbadry M, Moussa A. Does a tailored magnetic resonance imaging technique affect the surgical planning and outcomes for different cystic urethral and periurethral swellings in females? Seven years tertiary center experience. World J Urol. 2022 Jun;40(6):1587-1594.

69. Mandava A, Koppula V, Sharma G, Kandati M, Raju KVVN, Subramanyeshwar Rao T. Evaluation of genitourinary fistulas in pelvic malignancies with etiopathologic correlation: role of cross sectional imaging in detection and management. Br J Radiol. 2020 Jul;93(1111):20200049.

71. O'Shea A. Urologic Imaging: Infections and Inflammation. Urol Clin North Am. 2025 Feb;52(1):S0094-0143(24)00074-0.

73. Sekhar A, Eberhardt L, Lee KS. Imaging of the female urethra. Abdom Radiol (NY). 2019 Dec;44(12):3950-3961.

Disclaimer

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.

[a]The University of Texas MD Anderson Cancer Center, Houston, Texas. [b]Panel Chair, University of Chicago, Chicago, Illinois. [c]Panel Vice-Chair, Duke University Medical Center, Durham, North Carolina. [d]Memorial Sloan Kettering Cancer Center, New York, New York. [e]Mayo Clinic, Jacksonville, Florida. [f]McGill University, Montreal, Quebec, Canada. [g]Mayo Clinic, Rochester, Minnesota. [h]Urology Clinics of North Texas, Dallas, Texas; American Urological Association. [i]University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania; American Society of Nephrology. [j]University of Wisconsin, Madison, Wisconsin. [k]UPMC, Pittsburgh, Pennsylvania; American Urological Association. [l]Stanford University Medical Center, Stanford, California. [m]Ottawa Hospital Research Institute and the Department of Radiology, The University of Ottawa, Ottawa, Ontario, Canada. [n]Emory University Hospital, Atlanta, Georgia; Commission on Nuclear Medicine and Molecular Imaging. [o]National Institutes of Health, Bethesda, Maryland. [p]Specialty Chair, University of Alabama at Birmingham, Birmingham, Alabama.