American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Recurrent Lower Urinary Tract Infections in Women**

Variant 1: **With no underlying risk factors.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis without and with contrast	2		☢☢☢☢
X-ray abdomen	2		☢☢☢
CT abdomen and pelvis without contrast	2		☢☢☢☢
X-ray contrast enema	2		☢☢☢
X-ray cystography	2		☢☢☢
MRI pelvis without and with contrast	2	MRI may be indicated if urethral diverticulum is suspected.	O
US kidneys and bladder retroperitoneal	2		O
US pelvis (bladder)	2		O
Tc-99m sulfur colloid cystography	2		☢
X-ray voiding cystourethrography	2		☢☢
X-ray intravenous urography	1	Not cost-effective in this group. Has been supplanted by CT and MR urography.	☢☢☢
US pelvis (urethra)	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Clinical Condition: **Recurrent Lower Urinary Tract Infections in Women**

Variant 2: **Patients who are nonresponders to conventional therapy, get frequent reinfections or relapses, and have known underlying risk factors.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis without and with contrast	7		☢☢☢☢
MRI pelvis without and with contrast	6	For suspected diverticulum or prolapse. Favored for patients who require repeated imaging examinations. See statement regarding contrast in text under "Anticipated Exceptions."	O
US pelvis (urethra)	5	Favored for pregnant women.	O
X-ray voiding cystourethrography	4	For reflux, bladder or urethral fistula, or prolapse.	☢☢
X-ray intravenous urography	3	Limited use (or alternative) in young patients if MR is unavailable or not possible.	☢☢☢
US kidneys and bladder retroperitoneal	3	Less accurate for detection of pyelonephritis.	O
X-ray urethrography double balloon	2		☢☢
X-ray abdomen	2		☢☢☢
CT abdomen and pelvis without contrast	2		☢☢☢☢
X-ray contrast enema	2	May be useful for vesicoenteric fistula.	☢☢☢
X-ray cystography	2	May be useful for vesicoenteric fistula.	☢☢☢
US pelvis (bladder)	2	Also to evaluate for postvoid residual.	O
Tc-99m sulfur colloid cystography	2		☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Expert Panel on Urologic Imaging: Elizabeth Lazarus, MD[1]; David D. Casalino, MD[2]; Erick M. Remer, MD[3]; Ronald S. Arellano, MD[4]; Jay T. Bishoff, MD[5]; Courtney A. Coursey, MD[6]; Manjiri Dighe, MD[7]; Douglas F. Eggli, MD[8]; Pat Fulgham, MD[9]; Stanley Goldfarb, MD[10]; Gary M. Israel, MD[11]; John R. Leyendecker, MD[12]; Paul Nikolaidis, MD[13]; Nicholas Papanicolaou, MD[14]; Srinivasa Prasad, MD[15]; Parvati Ramchandani, MD[16]; Sheila Sheth, MD[17]; Raghunandan Vikram, MD.[18]

Summary of Literature Review

Urinary tract infections (UTI) are among the most common bacterial infections in women. Every year in the United States, about 15% of women are diagnosed with UTIs [1]. Most occur in healthy, sexually active women with a normal urinary tract and normal renal function [2]. These infections are usually limited to the lower urinary tract, are not recurrent, and respond to appropriate antimicrobial therapy [3]. Lower UTIs are confined to the bladder and occasionally the urethra and result in irritative voiding symptoms such as frequency, dysuria, urgency, and hematuria in severe cases. There is usually no associated flank pain, fever, or other systemic symptoms. Complicated UTIs are those occurring in patients with underlying structural or medical problems. Uncomplicated UTI is classified as UTI without structural or functional abnormalities of the urinary tract and without relevant comorbidities [2].

Recurrent lower UTIs are usually defined as at least three episodes of infection within the preceding 12 months [2]. Antibiotic prophylaxis is the most effective way to reduce recurrent UTIs [2]. 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) [2,4]. In fact, such lower UTIs are commonly referred to as "honeymoon cystitis." A clean-catch or catheterized specimen for culture typically reveals >100,000 organisms per milliliter of urine. The typical infecting organism is *Escherichia coli* [4]. The route of infection is ascending from the perianal area and vagina via the urethra and into the bladder. It is not at all uncommon for such infections to be severe enough to result in gross hematuria. Postmenopausal women are at increased risk for recurrent UTI in the presence of urinary incontinence, cystocele, or high postvoid residuals of urine [5-6].

Three-day antimicrobial regimens are effective in at least 90% of women [7]. Women who have three or more symptomatic infections over a 12-month period may benefit from prophylaxis [2,4]. In patients without underlying risk factors (Appendix 1) and with lower UTIs as defined above that do not exceed two episodes per year on average, and that respond promptly to appropriate therapy, imaging is usually not cost-effective [4].

"Relapses" of recurrent lower UTIs in women must be differentiated from "reinfection," which may indicate causes such as a vesicovaginal or vesicoenteric fistula or a paravesical abscess with fistula to the bladder [3,8-10]. 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" [4]. Causes of bacterial persistence include calculi, foreign bodies, urethral or bladder diverticula, infected urachal cyst, and postoperative changes such as a remaining ureteral stump that retains urine and results in stasis. In such patients with frequent relapses or reinfections, imaging is indicated to detect a treatable condition and monitor its progress.

Imaging Options

In support of the premise that imaging has little efficacy in uncomplicated lower UTIs in women, several studies [11-13] evaluating women with recurrent UTIs with intravenous urography (IVU) revealed no findings that altered the medical or surgical management. In an additional study by Fairchild et al [14], the 6% of patients with recurrent UTIs that demonstrated "major structural urologic abnormalities requiring further therapy" all had risk factors (to be defined subsequently).

Therefore, imaging studies should be reserved for women who do not respond promptly to appropriate antimicrobial therapy, those who suffer frequent reinfections or relapses, and those with known risk factors. Other documented risk factors include: childhood UTIs, flank pain, fever >38.5° C, history of urinary calculi or urinary tract obstruction, obstructive voiding symptoms (straining to urinate, feeling of incomplete bladder emptying, etc), infection with a urea-splitting organism, abnormal renal function studies, pelvic floor dysfunction, neurogenic bladder dysfunction, history of genitourinary surgery,

[1]Principal Author, Alpert Medical School of Brown University, Providence, Rhode Island.
[2]Panel Chair, Northwestern University, Chicago, Illinois.
[3]Panel Vice-chair, Cleveland Clinic, Cleveland, Ohio.
[4]Massachusetts General Hospital, Boston, Massachusetts.
[5]Intermountain Urological Institute, Murray, Utah, American Urological Association.
[6]Emory University Hospital, Atlanta, Georgia.
[7]University of Washington Medical Center, Seattle, Washington.
[8]Pennsylvania State University, Hershey, Pennsylvania, Society of Nuclear Medicine.
[9]Presbyterian Hospital of Dallas, Dallas, Texas, American Urological Association.
[10]University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania, American Society of Nephrology.
[11]Yale University School of Medicine, New Haven, Connecticut.
[12]Wake Forest University School of Medicine, Winston Salem, North Carolina.
[13]Northwestern University, Chicago, Illinois.
[14]Hospital of University of Pennsylvania, Philadelphia, Pennsylvania.
[15]University of Texas Health Science Center, San Antonio, Texas.
[16]University of Pennsylvania Hospital, Philadelphia, Pennsylvania.
[17]Johns Hopkins Hospital, Baltimore, Maryland.
[18]University of Texas MD Anderson Cancer Center, Houston, Texas.

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

asymptomatic bacteriuria, diabetes mellitus or other immunocompromised states, and analgesic abuse [11-14].

The following paragraphs discuss the various imaging examinations that may be useful in evaluating women with recurrent UTIs.

Radiography

Radiography of the abdomen has long been an important examination for detecting calculi, bladder wall calcifications, gas in the wall or lumen of the urinary bladder, and/or foreign bodies that may be the etiology of a UTI [3]. Use of digital tomosynthesis of the abdomen results in improved detection of urinary stones in general over digital radiography, with only a slight increase in effective dose [15].

When calcifications are seen in the bladder wall, it is often possible to make a correct clinical diagnosis if these findings are viewed in the context of the clinical history, physical examination, appropriate laboratory studies, and further imaging of the remainder of the urinary tract. Bladder wall calcification is typically due to prior infection with schistosomiasis (uncommon in the United States, but very common in other parts of the world), tuberculosis, cytoxan cystitis, or radiation cystitis [16].

Intravenous Urography

Historically, IVU was the imaging study of choice to evaluate the urinary tract. However, computed tomography (CT) and magnetic resonance urography have supplanted the use of IVU in many institutions [17]. IVU optimally includes thin-section nephrotomography, which may show renal scarring to indicate prior episodes of pyelonephritis. Although ill-defined renal margins may suggest a perirenal inflammatory process, complications of suspected pyelonephritis are best evaluated by CT. However, for evaluation of the collecting system, IVU may detect the changes caused by reflux nephropathy, papillary necrosis, and subtle urothelial neoplasms, as well as other changes associated with infections such as pyelitis cystica and leukoplakia. IVU is also useful for detecting or excluding congenital anomalies or obstruction of the urinary tract. The bladder phase of the IVU can usually identify contour abnormalities suggestive of inflammation or neoplasm. Further, the ability of the bladder to empty on voiding can be reasonably assessed. Cystoscopy is the best method to evaluate bladder wall pathology suspected on imaging studies. In patients with recurrent UTIs, investigators have found that 9 of 118 (8%) patients had abnormalities on cystoscopy. Additionally, patients with no underlying risk factors demonstrate a very high negative predictive value for cystoscopy [18].

The weaknesses of IVU include the lack of parenchymal detail and the inability to characterize filling defects. CT of the abdomen and pelvis without and with contrast and including high-resolution imaging during the excretory phase (CT urography) has superseded IVU [17,19-21].

Computed Tomography

CT without and with intravenous contrast has been described as the "examination of choice" in evaluating complicated UTIs for detecting underlying structural problems or complications [22-25]. CT is the modality of choice for evaluating acute bacterial nephritis. This is especially true in patients with known underlying risk factors, repeated episodes of reinfection, or persistent infection despite adequate therapy. CT can not only define the extent of disease but also identify complications such as renal and perirenal abscess which may be associated with these infections [8,26-27].

Although abdominal radiography is considered the most cost-effective imaging modality for detecting radio-opaque calculi associated with recurrent UTI, it may prove inadequate in some cases (eg, poor definition due to moderate overlying bowel, radiolucent calculi [28]). Its benefits include increased accuracy in detecting calculi (contrast resolution and lack of overlying bowel and bone), increased speed of examination, and increased abdominal detail, allowing, in some cases, an alternate diagnosis to explain patients' signs, symptoms, and laboratory findings [28]. As a result, 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 sometimes associated with recurrent UTIs. Reduced-radiation protocols for CT are being developed, which result in similar detection of renal stones while reducing patient radiation exposure [29].

Ultrasound

Some investigators [30] have advocated the use of renal and pelvic ultrasound (US) combined with radiographs as a replacement for IVU. They conclude that young women with recurrent UTIs should have this combination of examinations (ie, US and radiographs) as the investigation of choice because it is cost-effective, "noninvasive, inexpensive, and acceptable to the patient." US has the advantage of no ionizing radiation. US can efficiently measure postvoid residuals within the bladder and detect some bladder diverticula. However, it is less accurate in the detection of pyelonephritis when compared with other imaging modalities, including CT and magnetic resonance imaging (MRI) [31].

Magnetic Resonance Imaging

MRI has been shown to be useful in evaluating UTI [17,31-32]. It does not use ionizing radiation and therefore is favored in patient populations such as pregnant women, children, and patients who require repeated imaging examinations. 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 [5-6,33-34]. MRI best assesses the structure and complexity of urethral diverticula, allowing for accurate diagnosis and improved surgical planning [35]. Given the excellent soft-tissue contrast on MR imaging, this modality is also effective for evaluating vesicovaginal and enterovesicular fistulae [36-37].

MRI is less sensitive than CT for detecting urinary tract calculi. In a study of 149 patients, MR urography

demonstrated 69% sensitivity for detecting calculi vs 100% for CT [38]. MRI may be of greatest value in documenting active upper tract infection vs scar formation to determine whether therapy has been effective in the high-risk patient and in differentiating active infection from other complications post renal transplant [32].

Diverticula

Patients with suspected bladder diverticula may be imaged with cystography, US, or CT [19]. Bladder diverticula are unusual in women and are associated with neurogenic, or postoperative bladder, or rarely are congenital. When a bladder diverticulum is at or near a ureteral orifice, voiding cystourethrography should be considered to evaluate the possibility of vesicoureteral reflux [39]. Although used commonly in children to reduce the dose of radiation, nuclear cystography has not been used widely in adults.

A history of recurrent UTI is seen in 30%-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 [40-42]. MRI best assesses the structure and complexity of urethral diverticula, allowing for accurate diagnosis and improved surgical planning. In at least one report, MRI altered the surgical management in 15% of patients [35]. Double balloon urethrography can be technically difficult and may be uncomfortable for the patient. CT urethrography requires imaging postprocessing on a workstation.

When performing cystography and urethrography for evaluating the lower urinary tract, the use of digital radiography has been shown to decrease radiation dose by approximately 90% while maintaining diagnostic accuracy. This is particularly important in reducing the gonadal radiation dose during the examination of young women [43].

Enterovesical Fistulae

Enterovesical fistulae are usually caused by diverticulitis (cancer is the second most common cause). Clinical suspicion is frequently raised by the presence of UTI with pneumaturia and/or fecaluria. CT is the primary imaging modality for suspected cases of enterovesical fistulas [44-46]. Goldman et al [44] found that CT diagnosed 20 of 20 cases of enterovesical fistula. Kaufman et al found that CT revealed fistulas in 12 of 15 patients (80%). Cystoscopy was performed in 16 patients with 87.5% positive and barium enema in eight with 50% positive. The authors concluded that CT is the optimum imaging modality for diagnosis as it can also identify the underlying etiology [45]. The multiplanar imaging capability, lack of radiation, and high soft-tissue resolution inherent to MRI also makes this modality suitable for imaging suspected fistulae, particularly when repeat imaging and radiation doses are of issue [36-37]. IVU, colonoscopy US, upper gastrointestinal/small-bowel follow-through, sigmoidoscopy, and nuclear imaging have very low yields, making them even less cost-effective.

Summary

- Women with recurrent UTIs should have one or more additional risk factors to justify urologic or radiologic investigation.
- The basis for radiologic or urologic investigation of women with recurrent UTI is to detect abnormalities that could result in future morbidity. In such cases, cystoscopy may provide a cost-effective diagnosis.
- CT is a mainstream investigational modality for evaluating UTIs, especially in patients with underlying or known risk factors, episodes of reinfection, or infection resistant to conventional therapy.
- Abnormalities of the bladder and the urethra have traditionally been demonstrated with cystography and urethrography, respectively, with MRI now playing a more central role in evaluation of the urethra as well as for diagnosing bladder prolapse.
- For the detection of fistulae, CT is the optimum imaging technique and may also provide an etiology.

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^2), 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^2. For more information, please see the ACR *Manual on Contrast Media* [47].

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 NS (not specified).		

Supporting Document(s)

- ACR Appropriateness Criteria® Overview
- Procedure Information
- Evidence Table

References

1. Foxman B, Barlow R, D'Arcy H, Gillespie B, Sobel JD. Urinary tract infection: self-reported incidence and associated costs. *Ann Epidemiol* 2000; 10(8):509-515.
2. Wagenlehner FM, Weidner W, Naber KG. An update on uncomplicated urinary tract infections in women. *Curr Opin Urol* 2009; 19(4):368-374.
3. Stamey TA. Pathogenesis and treatment of urinary tract infections. Baltimore, MD: Williams & Wilkins. 1980:43-47; 179-199; 475-554.
4. Sheffield JS, Cunningham FG. Urinary tract infection in women. *Obstet Gynecol* 2005; 106(5 Pt 1):1085-1092.
5. 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.
6. Raz R, Gennesin Y, Wasser J, et al. Recurrent urinary tract infections in postmenopausal women. *Clin Infect Dis* 2000; 30(1):152-156.
7. Fihn SD. Clinical practice. Acute uncomplicated urinary tract infection in women. *N Engl J Med* 2003; 349(3):259-266.
8. Browne RF, Zwirewich C, Torreggiani WC. Imaging of urinary tract infection in the adult. *Eur Radiol* 2004; 14 Suppl 3:E168-183.
9. Schaeffer AJ. Infections of the urinary tract. In: Walsh J, et al, eds. *Campbell's urology*. 6th ed. Philadelphia, PA: WB Saunders; 1992:731-806.
10. Stamm WE. Cystitis and urethritis. In: Schrier RW, Gottschalk CW, eds. *Diseases of the kidney*. 5th ed. Boston, Mass: Little Brown; 1993:1007-1027.
11. De Lange EE, Jones B. Unnecessary intravenous urography in young women with recurrent urinary tract infections. *Clin Radiol* 1983; 34(5):551-553.
12. Engel G, Schaeffer AJ, Grayhack JT, Wendel EF. The role of excretory urography and cystoscopy in the evaluation and management of women with recurrent urinary tract infection. *J Urol* 1980; 123(2):190-191.
13. Fair WR, McClennan BL, Jost RG. Are excretory urograms necessary in evaluating women with urinary tract infection? *J Urol* 1979; 121(3):313-315.
14. Fairchild TN, Shuman W, Berger RE. Radiographic studies for women with recurrent urinary tract infections. *J Urol* 1982; 128(2):344-345.
15. 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* 2010; 195(1):161-167.
16. Pollack HM, Banner MP, Martinez LO, Hodson CJ. Diagnostic considerations in urinary bladder wall calcification. *AJR* 1981; 136(4):791-797.
17. 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.
18. 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.
19. Caoili EM, Cohan RH, Korobkin M, et al. Urinary tract abnormalities: initial experience with multi-detector row CT urography. *Radiology* 2002; 222(2):353-360.
20. Chow LC, Sommer FG. Multidetector CT urography with abdominal compression and three-dimensional reconstruction. *AJR* 2001; 177(4):849-855.
21. 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.
22. Baumgarten DA, Baumgartner BR. Imaging and radiologic management of upper urinary tract infections. *Urol Clin North Am* 1997; 24(3):545-569.
23. Mindelzun RE, Jeffrey RB. Unenhanced helical CT for evaluating acute abdominal pain: a little more cost, a lot more information. *Radiology* 1997; 205(1):43-45.
24. Smith RC, Rosenfield AT, Choe KA, et al. Acute flank pain: comparison of non-contrast-enhanced CT and intravenous urography. *Radiology* 1995; 194(3):789-794.
25. Smith RC, Verga M, McCarthy S, Rosenfield AT. Diagnosis of acute flank pain: value of unenhanced helical CT. *AJR* 1996; 166(1):97-101.
26. Stunell H, Buckley O, Feeney J, Geoghegan T, Browne RF, Torreggiani WC. Imaging of acute pyelonephritis in the adult. *Eur Radiol* 2007; 17(7):1820-1828.
27. Craig WD, Wagner BJ, Travis MD. Pyelonephritis: radiologic-pathologic review. *Radiographics* 2008; 28(1):255-277; quiz 327-258.
28. Sourtzis S, Thibeau JF, Damry N, Raslan A, Vandendris M, Bellemans M. Radiologic investigation of renal colic: unenhanced helical CT compared with excretory urography. *AJR* 1999; 172(6):1491-1494.
29. Jin DH, Lamberton GR, Broome DR, et al. Effect of reduced radiation CT protocols on the detection of renal calculi. *Radiology* 2010; 255(1):100-107.
30. McNicholas MM, Griffin JF, Cantwell DF. Ultrasound of the pelvis and renal tract combined with a plain film of abdomen in young women with urinary tract infection: can it replace intravenous urography? A prospective study. *Br J Radiol* 1991; 64(759):221-224.
31. 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.
32. Martina MC, Campanino PP, Caraffo F, et al. Dynamic magnetic resonance imaging in acute pyelonephritis. *Radiol Med* 2010; 115(2):287-300.
33. Boyadzhyan L, Raman SS, Raz S. Role of static and dynamic MR imaging in surgical pelvic floor dysfunction. *Radiographics* 2008; 28(4):949-967.
34. Woodfield CA, Krishnamoorthy S, Hampton BS, Brody JM. Imaging pelvic floor disorders: trend toward comprehensive MRI. *AJR* 2010; 194(6):1640-1649.
35. 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.
36. Healy JC, Phillips RR, Reznek RH, Crawford RA, Armstrong P, Shepherd JH. The MR appearance of vaginal fistulas. *AJR* 1996; 167(6):1487-1489.
37. Outwater E, Schiebler ML. Pelvic fistulas: findings on MR images. *AJR* 1993; 160(2):327-330.

38. 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.
39. Amar AD, Das S. Vesicoureteral reflux in women with primary bladder diverticulum. *J Urol* 1985; 134(1):33-35.
40. Chang YL, Lin AT, Chen KK. Presentation of female urethral diverticulum is usually not typical. *Urol Int* 2008; 80(1):41-45.
41. Chou CP, Huang JS, Wu MT, et al. CT voiding urethrography and virtual urethroscopy: preliminary study with 16-MDCT. *AJR* 2005; 184(6):1882-1888.
42. Chou CP, Levenson RB, Elsayes KM, et al. Imaging of female urethral diverticulum: an update. *Radiographics* 2008; 28(7):1917-1930.
43. Zoeller G, May C, Vosshenrich R, et al. Digital radiography in urologic imaging: radiation dose reduction on urethrocystography. *Urol Radiol* 1992; 14(1):56-58.
44. Goldman SM, Fishman EK, Gatewood OM, Jones B, Siegelman SS. CT in the diagnosis of enterovesical fistulae. *AJR* 1985; 144(6):1229-1233.
45. 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.
46. Yu NC, Raman SS, Patel M, Barbaric Z. Fistulas of the genitourinary tract: a radiologic review. *Radiographics* 2004; 24(5):1331-1352.
47. American College of Radiology. *Manual on Contrast Media*. Available at: http://www.acr.org/SecondaryMainMenuCategories/quality_safety/contrast_manual.aspx.

Appendix 1. Risk Factors

Risk Factors, Signs, and Symptoms	Underlying Condition
1. Flank pain	Obstruction and/or calculi
2. Infection with urea-splitting organism	Congenital abnormalities, sequelae of obstruction or infection, calculi (struvite)
3. Previous UTI or pyelonephritis	Congenital abnormalities and/or reflux
4. Fever (>38.5° C)	Infection and/or obstruction
5. History of calculi or obstruction	Congenital abnormalities, calculi, sequelae of obstruction or infection
6. Obstructive symptoms	Congenital abnormalities, calculi, sequelae of obstruction or infection
7. Elevated serum creatinine	Obstructive versus renal parenchymal disease
8. Asymptomatic bacteriuria	Calculi or foreign body
9. Severe diabetes mellitus	Renal/papillary abnormalities
10. Childhood UTI	Congenital abnormalities and/or reflux
11. Analgesic abuse	Renal/papillary abnormalities
12. Neurogenic bladder dysfunction	Stasis, bladder diverticula, reflux, calculi
13. History of genitourinary surgery	Congenital and/or postsurgical abnormalities
14. Suspected bladder diverticula	Bladder diverticula
15. Suspected urethral diverticula	Urethral diverticula
16. Suspected enterovesical fistula	Enterovesical fistula
17. Urinary incontinence	Infection, stasis (B)
18. Pelvic floor dysfunction	Cystocele, stasis
19. Post-void residuals	Stasis