

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

Clinical Condition: Acute Onset Flank Pain — Suspicion of Stone Disease

Variant 1: Suspicion of stone disease.

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
CT abdomen and pelvis without contrast	8	Reduced-dose techniques preferred.	High
X-ray intravenous urography	7		Med
US kidneys and bladder retroperitoneal with Doppler and KUB	6	Preferred examination in pregnancy, in patients who are allergic to iodinated contrast, and if NCT is not available.	Low
MRI abdomen and pelvis with or without contrast (MR urography)	4	See statement regarding contrast in text under “Anticipated Exceptions.”	None
X-ray abdomen (KUB)	1	Most useful in patients with known stone disease.	Low
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: Recurrent symptoms of stone disease.

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
CT abdomen and pelvis without contrast	7	Reduced-dose techniques preferred.	High
US kidneys and bladder retroperitoneal with Doppler and KUB	7		Low
X-ray abdomen (KUB)	6	Good for baseline and post-treatment follow-up.	Low
X-ray intravenous urography	2		Med
MRI abdomen and pelvis with or without contrast (MR urography)	2		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

ACUTE ONSET FLANK PAIN — SUSPICION OF STONE DISEASE

Expert Panel on Urologic Imaging: Deborah A. Baumgarten, MD, MPH¹; Isaac R. Francis, MD²; David D. Casalino, MD³; Ronald S. Arellano, MD⁴; Nancy S. Curry, MD⁵; Manjiri Dighe, MD⁶; Pat Fulgham, MD⁷; Gary M. Israel, MD⁸; John R. Leyendecker, MD⁹; Nicholas Papanicolaou, MD¹⁰; Srinivasa Prasad, MD¹¹; Parvati Ramchandani, MD¹²; Erick M. Remer, MD¹³; Sheila Sheth, MD.¹⁴

Summary of Literature Review

Urinary tract stones (calculi) are thought to result from either excessive excretion or precipitation of salts in the urine or a relative lack of inhibiting substances. Men are more commonly affected than women, and the incidence increases with age until age 60. Blacks and children are affected less frequently. Renal calculi tend to be recurrent, and flank pain is a nonspecific symptom that may be associated with other entities; therefore, evaluation with imaging is recommended at the initial presentation [1].

A renal calculus small enough to pass into the ureter may cause blockage of urine flow with distension of the upper urinary tract. Ureteral hyperperistalsis occurs, resulting in acute onset of sharp, spasmodic flank pain and hematuria. The ureter contains several areas where calculi commonly become lodged (eg, at the ureteropelvic junction) the iliac vessels, and the ureterovesical junction). The probability of spontaneous passage of a ureteral calculus measuring ≤ 5 mm in axial diameter is very high. A meta-analysis of five patient groups (224 patients) yielded an estimate that 68% of such stones would pass spontaneously (95% CI: 46%-85%) [2]. A 10 mm calculus, however, is very unlikely to pass spontaneously. Therefore, the treating physician wants to know the size of the calculus as well as its location and its effect on renal function.

Patients with a suspected diagnosis of renal colic have traditionally been evaluated with urinalysis, abdominal radiography (KUB), or excretory urography, commonly referred to as intravenous urography (IVU). More recently, ultrasonography (US), computerized

tomography (CT), and magnetic resonance imaging (MRI) have been used.

Radiography

Radiography of the abdomen may be sufficient to diagnose ureterolithiasis in patients with known stone disease and previous KUBs. The sensitivity of the KUB for ureterolithiasis in other patients is poor. Studies by Roth et al [3] and Mutgi et al [4] found sensitivities of 62% and 58% when the radiographs were interpreted retrospectively. Levine et al [5] correlated the KUB with noncontrast CT (NCT) retrospectively, so that an exact correlation was made between stones on the CT scan and the calcific density on the KUB. A sensitivity of only 59% was found for detecting ureteral calculi on the KUB. Ripolles et al [6] used the KUB as a guide for US evaluation of flank pain. They found 64% sensitivity for detecting ureteral calculi and had six false positive cases among the 66 patients evaluated. While the KUB may be a valuable part of the IVU or US evaluation of flank pain, it has a very limited role when used alone, and it should not be used to triage which patients should receive NCT.

Computed Tomography

Since the introduction of the use of helical (spiral) NCT as the initial study in evaluating flank pain by Smith et al [7], numerous investigations have confirmed it to be the study with the highest sensitivity (95%-96%) and specificity (98%) for ureterolithiasis [8-16]. Virtually all stones are radio-opaque, and stone size can be measured accurately in cross-section, aiding in predicting outcome. Stone location, accurately depicted by NCT, has also been associated with spontaneous stone passage rates, with the more proximal stones having a higher need for intervention [17]. Recently, coronal reconstruction of axial CT scans have been shown to more accurately predict stone size in the craniocaudal direction, although this dimension is not critical to estimating the likelihood of stone passage [18]. Review of coronal reformats has also been shown to increase the rate of detection of stones when reviewed with the axial dataset [19]. The degree of perinephric stranding present on the affected side on NCT has also been shown to correlate inversely with the likelihood of stone passage, giving additional prognostic information [9], but this finding has been disputed in other studies [20,21].

The amount of stranding is related to the time after onset of pain and is usually not seen in the first 2 hours following the onset of flank pain. It may take up to 8 hours after the onset of pain to become maximal [22]. Secondary signs such as ureteral dilatation and perinephric stranding allow CT to make a diagnosis of a recently passed stone [12,13]. NCT has been directly compared with IVU in four series [7,16,23,24]. NCT was equal to IVU in diagnosing obstruction and more reliable in diagnosing the presence of nephrolithiasis. NCT is also reliable for diagnosing flank pain due to causes other than ureterolithiasis [14,23-25] such as appendicitis,

¹Principal Author, Emory University Hospital, Atlanta, Georgia.

²Panel Chair, University of Michigan, Ann Arbor, Michigan.

³Panel Vice-chair, Northwestern University, Chicago, Illinois.

⁴Massachusetts General Hospital, Boston, Massachusetts.

⁵Medical University of South Carolina, Charleston, South Carolina.

⁶University of Washington Medical Center, Seattle, Washington.

⁷Presbyterian Hospital of Dallas, Dallas, Texas, American Urological Association.

⁸Yale University School of Medicine, New Haven, Connecticut.

⁹Wake Forest University School of Medicine, Winston Salem, North Carolina.

¹⁰Hospital of University of Pennsylvania, Philadelphia, Pennsylvania.

¹¹University of Texas Health Science Center, San Antonio, Texas.

¹²University of Pennsylvania Hospital, Philadelphia, Pennsylvania.

¹³Cleveland Clinic Foundation, Cleveland, Ohio.

¹⁴Johns Hopkins Hospital, Baltimore, Maryland.

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

diverticulitis, and torsed ovarian masses. NCT is safer than IVU since it uses no contrast media, is rapid (with the entire study taking minutes), and does not require the technical expertise that US does. When CT is available, it is the best first study in the nonpregnant adult presenting with flank pain likely to be due to stone disease, and it has been shown to be more cost-effective than IVU [24,26].

Concerns over radiation exposure, especially in young stone patients, have led to the development and evaluation of reduced-dose regimens [27-33]. Other recent technique refinement has included evaluation of the effect of slice width and overlapping image reconstruction on stone detection [34].

NCT using an ultra-low-dose protocol could also be considered, as was reported by White et al [35]. In this retrospective review of 20 pregnant patients (average gestational age = 26.5 weeks) with suspected renal colic, low-dose NCT (mean mAs, 109) confirmed stones in 13, severe hydronephrosis in two, and no significant findings in five.

Intravenous Urography

The IVU is the previous standard study for ureterolithiasis and is still the best investigation if NCT is not available. It provides information regarding site and degree of obstruction, size of stone, and effect of obstruction on renal excretion. This examination has a number of relative contraindications, including renal insufficiency, dehydration, past reaction to iodinated contrast agents, and pregnancy. The availability of nonionic iodinated contrast material has reduced the risk of reaction. It may take several hours for excretion to occur in the presence of acute obstruction, in which case it is more time-consuming than the alternative techniques. Another disadvantage is the inability of IVU to identify alternative diagnoses.

Ultrasound

US is a safe, noninvasive imaging modality that can be used to study the urinary tract effectively. The diagnosis of obstructive urinary tract calculi depends on identification of the offending calculus and concomitant pelvicaliectasis and ureterectasis extending to the obstructing site [36,37]. Because it may take many hours for pelvicaliectasis and ureterectasis to develop, US reportedly will miss over 30% of acute obstructions caused by a ureteral stone in patients who are not specifically hydrated for the study. Laing et al [38] and Svedstrom et al [39] detected hydronephrosis in seven of 20 nonhydrated patients (35%) and 16 of 22 nonhydrated patients (73%), respectively, with ureteral calculi. More recently, US has been found to be 100% sensitive for signs of obstruction (hydronephrosis, ureteral dilatation, and/or perirenal fluid), perhaps indicating improvement in US equipment [6]. The use of intrarenal Doppler US improves the detection of early obstruction by evaluating for elevated resistive index (RI) in kidneys with nondilated collecting systems [40,41].

Since KUB is superior to US in detecting ureteral calculi, Dalla Palma et al [42] have recommended a combination of KUB and US. US in these cases is used to detect ureteropyelocaliectasis and then to trace the dilated ureter to a shadowing stone. US can also evaluate the presence and type of ureteral jet (with obstruction the jets are absent, diminished significantly in frequency, or a constant slow trickle). In a series of 180 patients, the authors showed a 95% negative predictive value of the KUB/US combination, indicating that IVU is not likely to be helpful if the KUB/US tests are negative. However, IVU is indicated if the KUB/US combination is equivocal or if interventional treatment is anticipated.

Svedstrom et al [39] also performed a comparison of KUB, US, a combination of KUB/US, and IVU in 49 patients. The accuracies of KUB (61%) and US (69%) were lower than that of IVU (92%). The accuracy of the combination of KUB/US was 71%, still lower than that of IVU. In an effort to reduce the number of IVU examinations needed, a model was tested in which only patients with negative US results went on to have an IVU. This algorithm showed 93% sensitivity and 79% specificity. The KUB/US combination has also been compared to NCT [6]. In a prospective study of 66 patients, the KUB/US combination had a sensitivity of 79% (vs 93% for NCT) for detecting ureteral stones. All missed cases had spontaneous stone passage, leading the authors to conclude that after a negative KUB/US combination, NCT would not add useful information. They suggest use of NCT in patients who fail to respond to conservative management or in those in whom surgery is anticipated. The advantage of US is its lack of ionizing radiation and its ability to show some calculi. For this reason it has been suggested for evaluating stones in pregnant women [43]. Its disadvantages include the need for skilled personnel, its inability to accurately measure the size of the calculus, the need to observe the ureteral jet phenomenon at the ureterovesical junction, and its inability to differentiate dilatation without obstruction from true obstruction [44,45].

Magnetic Resonance Imaging

Regan et al [46] applied magnetic resonance urography (MRU) to the evaluation of 23 patients with acutely obstructed kidneys. They found 100% sensitivity for diagnosing obstruction, with perirenal fluid seen in 21 of 23 obstructed kidneys (87%) and in no normal kidneys. The site of the obstruction was seen in 80% of these obstructed kidneys. Round signal voids corresponding to the location of stones on correlative IVUs were seen in 12 of 18 patients with ureteric obstruction caused by a stone. These appearances were nonspecific and were also seen secondary to blood clot or tumor. Zielonko et al [47] examined 60 patients with obstructive uropathy. In the 13 patients with ureteric stones, MRU correctly identified the site of obstruction in 12 (one stone moved between the MRU and confirmatory imaging). Forty-six percent of the stones were seen as signal voids against a background of bright urine on T2-weighted images. MRU has been

successfully used in pregnant patients with flank pain [48].

Recurrent Symptoms of Stone Disease

In addition to pregnant patients, the patient with known stone disease and recurrent symptoms also presents a challenge. In this setting, the likelihood of stone disease as the cause of flank pain is higher [8], but repeated NCTs raise a concern about excessive radiation exposure. Katz et al [49] examined the issue of radiation exposure associated with repetitive NCT in this setting. In a 6-year period, 5,564 NCTs were performed for renal colic. While the vast majority of patients (96%) underwent one or two NCTs with an estimated effective dose of 6.5-17 mSv, 176 patients had three or more NCTs with an estimated dose of 20-154 mSv. One patient had 18 NCTs over the 6 years.

An additional study of this problem was recently published in the emergency medicine literature by Broder et al [50]. In this retrospective study of 356 patient encounters representing 306 individuals seen in the emergency department over a period of 10 months for suspected renal colic, 262 encounters included NCT. While 49 of the patients did not undergo CT scanning, 14 had one NCT, 151 (49%) had two NCTs, and 92 had three or more NCTs in the emergency department. This final group included a 28-year-old woman with 14 scans, a 42-year-old woman with 22 scans, and a 53-year-old man with 25 scans. In this setting, every effort should be made to use low-dose NCT. A recent study by Poletti et al found excellent sensitivity (95%) and specificity (97%) for detecting stones with a low-dose protocol (30 mA) compared to a standard-dose protocol (180 mA) in patients with a body mass index (BMI) of <30 [32].

In another recent study, Mulkens et al [33] studied 300 patients, half of whom underwent standard-dose NCT (95-120 mAs) and half of whom underwent low-dose NCT (51-70 mAs), and found high sensitivity (97.3%-98.6%) and specificity (93.5%) for detecting urinary tract stones in the low-dose group (comparable to the high-dose group). These excellent results may in part be due to the use of dose modulation. In the subset of obese or overweight patients, sensitivity and specificity were also high (97%-100%), leading them to conclude that low-dose NCT is a viable examination even in larger patients. Further, if the patient has persistence of symptoms from a documented stone and repeat imaging is contemplated, a limited NCT of the area of the stone through the bladder could be considered if stone passage is the main question. Alternatively, if the stone can be seen by KUB, a repeat KUB might provide useful information at a much lower dose.

Summary

- NCT is the most rapid and accurate technique for evaluating flank pain.
- If there is uncertainty about whether a calcific density represents a ureteral calculus or a phlebolith, contrast

medium can be injected and the scan repeated for definitive diagnosis.

- IVU, which is readily available and is familiar to nonradiologic physicians, is the technique of choice if CT is not available.
- In pregnant patients with flank pain, US is the best initial study.
- While a limited IVU has been used to evaluate flank pain in pregnancy when the US study is not diagnostic, MRU has potential utility in diagnosing acute urinary tract obstruction without the use of ionizing radiation.
- NCT using an ultra-low-dose protocol could also be considered.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m²), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m². For more information, please see the [ACR Manual on Contrast Media](#) [51].

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](#)

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