

**Acute Onset Flank Pain — Suspicion of Stone Disease**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Ha M, MacDonald RD. Impact of CT scan in patients with first episode of suspected nephrolithiasis. <i>J Emerg Med</i> 2004; 27(3):225-231.	Observational	121 patients had CT	Prospective observational study to evaluate use of HCT in first episode of suspected nephrolithiasis.	CT scanning is recommended in patients. It enhances physician diagnostic certainty by identifying alternate diagnoses and significant pathology not suspected on clinical grounds alone.	2
2. Preminger GM, Tiselius HG, Assimos DG, et al. 2007 guideline for the management of ureteral calculi. <i>J Urol</i> 2007; 178(6):2418-2434.	Review/Other	N/A	Practice guideline for the management of ureteral calculi. Systematic review of literature published since 1997 and an analysis of outcomes data from identified studies was performed.	Panel concluded based on findings that when removal becomes necessary, shock-wave lithotripsy and ureteroscopy remain the two primary treatment modalities for the management of symptomatic ureteral calculi.	4
3. Roth CS, Bowyer BA, Berquist TH. Utility of the plain abdominal radiograph for diagnosing ureteral calculi. <i>Ann Emerg Med</i> 1985; 14(4):311-315.	Observational	206 patients	Retrospective study to determine the usefulness of KUB for detection of ureteral calculi.	KUB had 92 true-positives (45%), 19 false-positives (9%), and 39 true negatives (19%), yielding a sensitivity of 62% and specificity of 67%. In patients with a high estimated clinical probability of a ureteral calculus, KUB had PPV of 86% and NPV of 22%. In the remaining patients, PPV was 69% and NPV was 72%, respectively. Each patient's clinical index score was compared to his or her excretory urogram results. For detecting ureteral calculi, the sensitivity of scoring index was 82%, and the specificity was 51%; PPV of scoring index was 82%, and NPV was 52%.	2
4. Mutgi A, Williams JW, Nettleman M. Renal colic. Utility of the plain abdominal roentgenogram. <i>Arch Intern Med</i> 1991; 151(8):1589-1592.	Observational	85 consecutive patients	Retrospective cohort study to evaluate the value of KUB compared with clinical evaluation alone in diagnosis and treatment of renal colic.	For KUB, sensitivity and specificity were 58% (95% CI, 47%-69%) and 69% (95% CI, 44%-94%), respectively. In population with a stone prevalence of 85%, the PPV was 91%. Clinical scoring system had sensitivity, of 73%; specificity of 46%; and PPV of 88%. KUB has low sensitivity and specificity and improves the predictive value only marginally, and its routine use is not cost-effective.	3
5. Levine JA, Neitlich J, Verga M, Dalrymple N, Smith RC. Ureteral calculi in patients with flank pain: correlation of plain radiography with unenhanced helical CT. <i>Radiology</i> 1997; 204(1):27-31.	Observational	178 patients	Retrospective review to determine the sensitivity and specificity of radiography for the detection of ureteral calculi. HCT is used as the standard of reference.	Original reading; sensitivity of 45% and a specificity of 77%. Blinded retrospective reading; sensitivity of 59% and a specificity of 71%. Unblinded retrospective reading; sensitivity of 59% (95% CI: 47%, 70%). Radiography is of limited value.	2

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6. Ripolles T, Agramunt M, Errando J, Martinez MJ, Coronel B, Morales M. Suspected ureteral colic: plain film and sonography vs unenhanced helical CT. A prospective study in 66 patients. <i>Eur Radiol</i> 2004; 14(1):129-136.	Observational	66 patients	Prospective study to compare value of KUB plus US with nonenhanced CT for the diagnosis of ureteral colic in patients with acute flank pain.	CT had greater sensitivity (93% vs 79%) and NPV (71% vs 46%) for the detection of lithiasis. Combination of lithiasis plus obstructive signs showed sensitivity and a specificity of 100% for CT and of 100% and 90%, respectively, for US. CT is the most accurate technique for the detection of ureteral lithiasis but the combination of radiograph and US is an alternative to nonenhanced CT with a lower sensitivity and radiation dose that has a good practical value.	2
7. 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. <i>AJR</i> 2010; 195(1):161-167.	Observational	50 consecutive patients, 3 blinded reviewers	Prospective study. Comparison of diagnostic performance of digital tomosynthesis and digital radiography for detection of renal calculi with noncontrast CT used as the gold standard. Images from all examinations were randomly read radiologists.	Digital tomosynthesis performed better than digital radiography for detection of renal calculi but not for detection of ureteral calculi. Mean effective radiation dose was 0.5 mSv for digital radiography, 0.85 mSv for tomosynthesis, 2.5 mSv for low-dose MDCT, and 12.6 mSv for high-dose MDCT.	2
8. Smith RC, Rosenfield AT, Choe KA, et al. Acute flank pain: comparison of non-contrast-enhanced CT and intravenous urography. <i>Radiology</i> 1995; 194(3):789-794.	Observational	20 patients	To compare noncontrast-enhanced CT and IVU in the evaluation of patients with acute flank pain.	Two techniques are equally effective in identification of obstruction; CT superior for identification of ureteric stones.	2
9. Abramson S, Walders N, Applegate KE, Gilkeson RC, Robbin MR. Impact in the emergency department of unenhanced CT on diagnostic confidence and therapeutic efficacy in patients with suspected renal colic: a prospective survey. 2000 ARRS President's Award. American Roentgen Ray Society. <i>AJR</i> 2000; 175(6):1689-1695.	Observational	93 patients	Prospective study to evaluate the impact of unenhanced CT on clinician diagnostic confidence and therapeutic efficacy in patients with suspected renal colic.	Unenhanced CT significantly altered confidence and treatment decisions in patients with suspected renal colic.	3
10. Boridy IC, Kawashima A, Goldman SM, Sandler CM. Acute ureterolithiasis: nonenhanced helical CT findings of perinephric edema for prediction of degree of ureteral obstruction. <i>Radiology</i> 1999; 213(3):663-667.	Observational	82 patients	Retrospective review to determine whether the extent of perinephric edema on HCT images without contrast material enhancement can be used to predict the degree of ureteral obstruction in patients with acute ureterolithiasis. CT and excretory urographic images in were reviewed.	Extent of edema allowed accurate prediction of the degree of ureteral obstruction in 44/47 (94%) patients with acute ureterolithiasis.	3
11. Katz DS, Lane MJ, Sommer FG. Unenhanced helical CT of ureteral stones: incidence of associated urinary tract findings. <i>AJR</i> 1996; 166(6):1319-1322.	Review/Other	54 patients	Retrospective review to determine the incidence of urinary tract findings associated with ureteral stones on unenhanced HCT scans of patients with acute renal colic.	Findings provided supportive evidence of acute obstruction.	4

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12. Smith RC, Verga M, Dalrymple N, McCarthy S, Rosenfield AT. Acute ureteral obstruction: value of secondary signs of helical unenhanced CT. <i>AJR</i> 1996; 167(5):1109-1113.	Observational	220 patients	To determine the value of secondary signs of ureteral obstruction on HCT.	The sensitivity of each secondary sign was ureteral dilatation 90%; perinephric stranding 82%; collecting system dilatation 83%; and renal enlargement 71%. The specificity of each secondary sign was ureteral dilatation 93%; perinephric stranding 93%; collecting system dilatation 94%; and renal enlargement 89%. Ureteral dilatation and perinephric stranding were either present or both absent in 181 of the 220 patients with a confirmed diagnosis. In this subgroup, this combination of signs had a PPV of 99% and NPV of 95%.	2
13. Smith RC, Verga M, McCarthy S, Rosenfield AT. Diagnosis of acute flank pain: value of unenhanced helical CT. <i>AJR</i> 1996; 166(1):97-101.	Observational	210 patients	To determine the value of unenhanced CT in the diagnosis of acute flank pain.	Sensitivity of 97%, specificity of 96%, and accuracy of 97% for diagnosis of ureteral stone disease. Unenhanced CT is an accurate technique.	2
14. Sourtzis S, Thibau JF, Damry N, Raslan A, Vandendris M, Bellemans M. Radiologic investigation of renal colic: unenhanced helical CT compared with excretory urography. <i>AJR</i> 1999; 172(6):1491-1494.	Observational	53 patients	Prospective study to compare unenhanced HCT with excretory urography in the patients with renal colic.	CT better than urography in identifying ureteral stones.	1
15. Coll DM, Varanelli MJ, Smith RC. Relationship of spontaneous passage of ureteral calculi to stone size and location as revealed by unenhanced helical CT. <i>AJR</i> 2002; 178(1):101-103.	Observational	172 patients	To study the relationship of spontaneous passage of ureteral calculi to stone size and location as revealed by unenhanced HCT.	Rate of spontaneous passage of ureteral stones varies with stone size and location.	3
16. Nadler RB, Stern JA, Kimm S, Hoff F, Rademaker AW. Coronal imaging to assess urinary tract stone size. <i>J Urol</i> 2004; 172(3):962-964.	Observational	102 patients with 151 stones	Retrospective review of CT images to determine if coronal reconstructions can help assess stone size.	Mean area in the axial and coronal reconstruction groups was 22.23 and 31.29 mm, respectively. Mean greatest axial dimension (length or width) was 4.87 mm and mean greatest coronal dimension (cephalocaudal length) was 6.51 mm. Cephalocaudal length estimated from axial images was 8.8 mm. Differences for all 3 of these comparisons (axial vs coronal area, greatest axial vs coronal dimension and estimated vs actual cephalocaudal length) proved to be statistically significant ( $P<0.0001$ ). Coronal reconstructions improved accuracy of stone measurements.	3

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17. Lin WC, Uppot RN, Li CS, Hahn PF, Sahani DV. Value of automated coronal reformations from 64-section multidetector row computerized tomography in the diagnosis of urinary stone disease. <i>J Urol</i> 2007; 178(3 Pt 1):907-911; discussion 911.	Observational	72 patients	To determine the value of automated coronal reformations from 64-detector CT in the detection of renal stones in patients suspected of having renal colic.	Review of coronal reformatted images alone revealed a higher number of stones than axial images alone with a faster reading time. Adding the coronal images to the axial images aided in the detection of renal stones over axial images alone.	2
18. Metser U, Ghai S, Ong YY, Lockwood G, Radomski SB. Assessment of urinary tract calculi with 64-MDCT: The axial versus coronal plane. <i>AJR</i> 2009; 192(6):1509-1513.	Observational	80 consecutive CT exams	To compare size measurements, detection rate, and conspicuity of renal calculi in coronal images as compared to axial images.	Estimation of maximum stone diameter, detection rate of stones, and conspicuity of stones 5 mm or smaller in diameter were improved with coronal reformations.	2
19. Memarsadeghi M, Schaefer-Prokop C, Prokop M, et al. Unenhanced MDCT in patients with suspected urinary stone disease: do coronal reformations improve diagnostic performance? <i>AJR</i> 2007; 189(2):W60-64.	Observational	147 consecutive patients	To evaluate whether coronal reformations in combination with axial images improve determination of number, size and location of urinary calculi and detection of alternative diagnoses.	Detection of renal calculi and determination of location was not improved with coronal reformations. Coronal reformations decreased interpretation time but were less sensitive than axial images in making alternative diagnoses.	2
20. Bird VG, Gomez-Marin O, Leveillee RJ, Sfakianakis GN, Rivas LA, Amendola MA. A comparison of unenhanced helical computerized tomography findings and renal obstruction determined by furosemide 99m technetium mercaptoacetyltriglycine diuretic scintirenography for patients with acute renal colic. <i>J Urol</i> 2002; 167(4):1597-1603.	Observational	77 patients	Blinded retrospective review to assess unenhanced HCT secondary findings as predictors of renal obstruction as determined by diuretic scintirenography, and to determine their reproducibility. Unenhanced CT findings were compared to those of diuretic scintirenography.	No significant difference in terms of CT findings between patients diagnosed by diuretic scintirenography as having high grade/complete obstruction and those with partial obstruction. Analyses showed that each unenhanced HCT finding, except for renal parenchymal edema and urinary extravasation, was a significant predictor of “any degree of obstruction”.	2
21. Boulay I, Holtz P, Foley WD, White B, Begun FP. Ureteral calculi: diagnostic efficacy of helical CT and implications for treatment of patients. <i>AJR</i> 1999; 172(6):1485-1490.	Observational	99 patients	Retrospective review to evaluate the diagnostic efficacy of unenhanced HCT and implications for treatment of patients with acute renal colic.	51 CT scans were positive for calculi, 48 were negative for calculi. Sensitivity 100%, specificity 96%, accuracy 98%. No statistically significant difference between the conservatively and interventionally treated groups with respect to stone location.	3
22. Varanelli MJ, Coll DM, Levine JA, Rosenfield AT, Smith RC. Relationship between duration of pain and secondary signs of obstruction of the urinary tract on unenhanced helical CT. <i>AJR</i> 2001; 177(2):325-330.	Observational	227 consecutive patients	To examine the relationship between duration of flank pain and the frequency of secondary signs of ureteral obstruction on unenhanced HCT.	All CT secondary signs of ureteral obstruction except nephromegaly showed a significant increase in frequency as duration of flank pain increased. Knowledge of the duration of pain is important when interpreting unenhanced CT studies in patients with acute ureterolithiasis.	3

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23. Takahashi N, Kawashima A, Ernst RD, et al. Ureterolithiasis: can clinical outcome be predicted with unenhanced helical CT? <i>Radiology</i> 1998; 208(1):97-102.	Observational	69 patients	To determine if unenhanced HCT can predict a favorable outcome in ureterolithiasis.	Amount of perinephric fat stranding and presence of perinephric fluid collections are helpful predictors of stone passage.	2
24. Eikefjord E, Askildsen JE, Rorvik J. Cost-effectiveness analysis (CEA) of intravenous urography (IVU) and unenhanced multidetector computed tomography (MDCT) for initial investigation of suspected acute ureterolithiasis. <i>Acta Radiol</i> 2008; 49(2):222-229.	Review/Other	119 patients	To compare the cost and effectiveness of IVU and unenhanced MDCT in the initial evaluation of renal colic.	MDCT had lower differential costs and a greater accuracy for determining stone disease than IVU in patients with acute flank pain and is a dominant alternative to IVU when evaluated from a cost-effective perspective.	4
25. Hoppe H, Studer R, Kessler TM, Vock P, Studer UE, Thoeny HC. Alternate or additional findings to stone disease on unenhanced computerized tomography for acute flank pain can impact management. <i>J Urol</i> 2006; 175(5):1725-1730; discussion 1730.	Review/Other	1,500 patients	To evaluate how many patients with renal colic had relevant alternative or additional findings on unenhanced CT.	14% had other findings requiring immediate or deferred treatment. Only 7% of studies were completely normal. Unenhanced CT allows accurate diagnosis of urinary stone disease and can provide further important information leading to emergency or deferred treatment.	4
26. Pfister SA, Deckart A, Laschke S, et al. Unenhanced helical computed tomography vs intravenous urography in patients with acute flank pain: accuracy and economic impact in a randomized prospective trial. <i>Eur Radiol</i> 2003; 13(11):2513-2520.	Experimental	122 patients	Prospective randomized study to assess and compare the accuracy and economic impact of unenhanced HCT with IVU in patients with acute flank pain.	Unenhanced CT had sensitivity of 94.1% and specificity of 94.2%. IVU had sensitivity of 85.2% and specificity of 90.4%. Unenhanced CT was more cost effective than IVU for the evaluation of patients with stone disease.	1
27. Dalla Palma L, Pozzi-Mucelli R, Stacul F. Present-day imaging of patients with renal colic. <i>Eur Radiol</i> 2001; 11(1):4-17.	Review/Other	N/A	To illustrate the contribution of unenhanced HCT to the study of patients with renal colic and analyze the advantages and shortcomings of the technique compared with other diagnostic approaches.	HCT should be the first choice in imaging a patient with renal colic. If this technique is not available, plain film and US should be considered adding urography in unresolved cases.	4

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28. Kawashima A, Sandler CM, Boridy IC, Takahashi N, Benson GS, Goldman SM. Unenhanced helical CT of ureterolithiasis: value of the tissue rim sign. <i>AJR</i> 1997; 168(4):997-1000.	Observational	59 patients, 4 reviewers	To determine the prevalence of the tissue rim sign in patients with ureterolithiasis and extraurinary calcifications and to determine the relationship between the tissue rim sign, the size of a calculus, and the degree of urinary obstruction using unenhanced HCT.	32 patients each had a single ureteral calculus. Of these patients, CT revealed a positive tissue rim sign in 16 patients (50%), was negative in 5 patients (16%), and was indeterminate in 11 patients (34%). 57 extraurinary calcifications was observed in 18 patients (11 patients with ureteral calculi and 7 patients without ureteral calculi). None of the 57 extraurinary calcifications was associated with a positive tissue rim sign. The tissue rim sign was negative in 39 (68%) of the 57 extraurinary calcifications and indeterminate in the remaining 18 (32%). Ureteral calculi with a negative tissue rim sign were larger than ureteral calculi with a positive tissue rim sign ( $P<.01$ ). A high degree of obstruction was present in 4/5 patients with ureteral calculi for which CT showed a negative tissue rim sign. Conversely, 6/16 patients in whom CT revealed a positive tissue rim sign also had a high degree of obstruction. Therefore, no clear relationship was found between the degree of obstruction and the presence of a positive tissue rim sign. A positive tissue rim sign is specific for the diagnosis of ureterolithiasis. However, a negative tissue rim sign does not preclude such a diagnosis. The presence or absence of this tissue rim sign correlates with the size of a calculus but not with the degree of urinary obstruction. When CT reveals an indeterminate tissue rim sign, careful inspection for other CT findings, such as ipsilateral ureteral dilatation, perinephric edema, dilatation of the intrarenal collecting system, and renal swelling, is necessary.	3
29. Kalra MK, Maher MM, Toth TL, et al. Strategies for CT radiation dose optimization. <i>Radiology</i> 2004; 230(3):619-628.	Review/Other	N/A	To review basic principles of CT radiation exposure and strategies for CT radiation dose optimization.	Strategies for radiation dose reduction are difficult to devise because of minimum guidelines on CT examination and scanning techniques.	4

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30. Heneghan JP, McGuire KA, Leder RA, DeLong DM, Yoshizumi T, Nelson RC. Helical CT for nephrolithiasis and ureterolithiasis: comparison of conventional and reduced radiation-dose techniques. <i>Radiology</i> 2003; 229(2):575-580.	Observational	50 patients	Prospective recruitment with retrospective review. To determine the accuracy of unenhanced HCT performed at reduced milliamperes-second, and therefore at a reduced patient radiation dose. Conventional unenhanced CT is used as the standard.	In patients with weight <200 lb, unenhanced HCT performed at a reduced tube current of 100 mA, and therefore at a reduced patient dose, resulted in scans of high accuracy.	1
31. Liu W, Esler SJ, Kenny BJ, Goh RH, Rainbow AJ, Stevenson GW. Low-dose nonenhanced helical CT of renal colic: assessment of ureteric stone detection and measurement of effective dose equivalent. <i>Radiology</i> 2000; 215(1):51-54.	Observational	60 patients	Prospective study to evaluate low dose nonenhanced HCT protocol in detection of ureteric stone and measurement of effective dose equivalent. IVU images and other clinical images were used as standards of reference.	CT showed 36/37 ureteric stones, and one false-positive case was recorded for sensitivity of 97%, specificity of 96%, and accuracy of 97%. Low-dose CT protocol is superior to IVU and clinically adequate for diagnosis of renal colic.	2
32. Meagher T, Sukumar VP, Collingwood J, et al. Low dose computed tomography in suspected acute renal colic. <i>Clin Radiol</i> 2001; 56(11):873-876.	Observational	69 patients	Prospective multicenter study to determine if CT of the renal tract in suspected renal colic using reduced exposure factors maintains diagnostic accuracy. IVU and clinical records as gold standard.	Although CT had a higher radiation dose, it was more accurate than IVU.	2
33. Tack D, Sourtzis S, Delpierre I, de Maertelaer V, Gevenois PA. Low-dose unenhanced multidetector CT of patients with suspected renal colic. <i>AJR</i> 2003; 180(2):305-311.	Observational	106 patients	To evaluate inter-and intra-observer agreement and diagnostic performance of low dose unenhanced MDCT protocol.	36/38 ureteral stones were detected by low-dose MDCT. From reviewer to reviewer, the number of true-positive, false-positive, true-negative, and false-negative findings ranged, respectively, from 34 to 36, 1 to 4, 64 to 68, and 2 to 4. The corresponding sensitivity, specificity, and accuracy ranged from 89.5%-94.7%, from 94.1%-100%, and from 93.4%-98.1%, respectively. Inter-and intra-observer agreement (kappa values ranged from 0.87 to 0.98).	2
34. Poletti PA, Platon A, Rutschmann OT, Schmidlin FR, Iselin CE, Becker CD. Low-dose versus standard-dose CT protocol in patients with clinically suspected renal colic. <i>AJR</i> 2007; 188(4):927-933.	Observational	125 patients	To evaluate low-dose CT by comparing low-dose CT protocol (30mAs) with standard-dose (180mA) scans in patients with suspected renal colic.	In patients with a body mass index of <30, low-dose scans had a sensitivity of 96% and specificity of 100% for indirect signs of renal colic and 95% sensitivity and 97% specificity for detecting ureteral stones. Interobserver agreement was near perfect (kappa=0.97 ± 0.02 for stones). Estimation of stone size may vary by ± 20% on low dose study compared to standard dose.	2

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35. Mulkens TH, Daineffe S, De Wijngaert R, et al. Urinary stone disease: comparison of standard-dose and low-dose with 4D MDCT tube current modulation. <i>AJR</i> 2007; 188(2):553-562.	Observational	300 patients	Prospective blinded study to compare the performance of standard-dose and low-dose with 4D MDCT tube current modulation in patients with renal colic.	Sensitivity of low-dose exams interpreted by two experienced reviewers was 97.3%-98.6%; specificity, 93.5%; and accuracy, 95.3%. Sensitivity of low-dose examinations of overweight and obese patients was 97%-100%; specificity, 100%, and accuracy 98%-100%. Interobserver agreement for urinary stone detection was excellent between the two reviewers, with kappa values of 0.98 for the low-dose and 0.96 for the standard-dose exams.	2
36. White WM, Zite NB, Gash J, Waters WB, Thompson W, Klein FA. Low-dose computed tomography for the evaluation of flank pain in the pregnant population. <i>J Endourol</i> 2007; 21(11):1255-1260.	Observational	20 patients	To retrospectively review the use of low-dose CT in pregnant patients with flank pain.	13/20 patients were proven to have renal colic at what the authors considered a low risk of fetal harm from radiation exposure. Low-dose CT is highly sensitive and specific for the detection of urinary calculi in pregnant patients.	3
37. Jin DH, Lamberton GR, Broome DR, et al. Effect of reduced radiation CT protocols on the detection of renal calculi. <i>Radiology</i> 2010; 255(1):100-107.	Observational	57 patients	To determine, using calculi placed in cadaver kidneys, the effect of reduced radiation dose (100, 60, and 30 mAs) on the sensitivity and specificity of MDCT for detection of renal calculi.	Decreasing tube charge from 100 mAs to 30 mAs did not significantly alter the detection of renal calculi.	2
38. Ciaschini MW, Remer EM, Baker ME, Lieber M, Herts BR. Urinary calculi: radiation dose reduction of 50% and 75% at CT--effect on sensitivity. <i>Radiology</i> 2009; 251(1):105-111.	Observational	47 consecutive patients, 141 reconstructions, 2 blinded reviewers	To retrospectively determine the effect of 50% and 75% dose reduction on sensitivity and specificity of CT for the detection of urinary calculi. All reconstructed examinations were randomized and evaluated by two radiologists blinded to the presence, number, location, and size of calculi.	For all calculi, the blinded readers demonstrated combined sensitivities of 91.7%, 83.3%, and 67.1% for the 100%, 50%, and 25% tube current reconstructions, respectively. For stones >3 mm, combined sensitivities were 97.7%, 93.0%, and 91.9%, respectively, for the 100%, 50%, and 25% reconstructions. There was no significant difference between the 100% examinations and the 50% and 25% reconstructions for detection of stones >3 mm (P=.106 and .099, respectively). There were no significant differences between the 100% examinations and the 50% and 25% examinations for the detection of calculi >3 mm.	2
39. Niemann T, Kollmann T, Bongartz G. Diagnostic performance of low-dose CT for the detection of urolithiasis: a meta-analysis. <i>AJR</i> 2008; 191(2):396-401.	Review/Other	7 studies with 1061 patients	A meta-analysis evaluating low-dose CT (<3 mSv) for detection of urinary calculi.	Pooled sensitivity and specificity of low-dose CT for the diagnosis of urinary calculi were 0.966 and 0.949, respectively.	4



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40. Memarsadeghi M, Heinz-Peer G, Helbich TH, et al. Unenhanced multi-detector row CT in patients suspected of having urinary stone disease: effect of section width on diagnosis. <i>Radiology</i> 2005; 235(2):530-536.	Observational	147 patients	Prospective study to assess the effect of section width in MDCT evaluation of patients with acute flank pain who are suspected of having or known to have urinary stone disease.	No difference between 1.5 and 3 mm slice width but 5 mm slice width found significantly fewer renal and ureteral stones. Overlapping 3-mm sections are sufficient for the detection of urinary stone disease.	2
41. Kambadakone AR, Eisner BH, Catalano OA, Sahani DV. New and evolving concepts in the imaging and management of urolithiasis: urologists' perspective. <i>Radiographics</i> 2010; 30(3):603-623.	Review/Other	N/A	Review imaging and management of urolithiasis with emphasis on role of CT.	CT has been the investigation of choice for the evaluation of urinary stone disease. The emergence of MDCT and the recent introduction of dual-energy CT have further reinforced the superiority of this modality over other imaging techniques in the management of urolithiasis.	4
42. Grosjean R, Sauer B, Guerra RM, et al. Characterization of human renal stones with MDCT: advantage of dual energy and limitations due to respiratory motion. <i>AJR</i> 2008; 190(3):720-728.	Observational	241 human renal stones	To determine the composition of urinary calculi using CT attenuation values and a jelly phantom.	Dual-energy CT attenuation values could be used to determine urinary calculus composition but performance was degraded when respiratory motion was simulated.	3
43. Boll DT, Patil NA, Paulson EK, et al. Renal stone assessment with dual-energy multidetector CT and advanced postprocessing techniques: improved characterization of renal stone composition--pilot study. <i>Radiology</i> 2009; 250(3):813-820.	Observational	50 renal calculi	To prospectively evaluate the capability of noninvasive, simultaneous dual-energy MDCT to improve characterization of human renal calculi in an anthropomorphic dual energy renal phantom by introducing advanced postprocessing techniques, with ex vivo renal stone spectroscopy as the reference standard.	Dual-energy CT with advanced post-processing techniques can be used to determine urinary calculus composition.	3
44. Erwin BC, Carroll BA, Sommer FG. Renal colic: the role of ultrasound in initial evaluation. <i>Radiology</i> 1984; 152(1):147-150.	Observational	21 patients	Prospective study to determine role of US in initial evaluation of renal colic.	US equal to IVU in detecting calculi.	3
45. Hill MC, Rich JJ, Mardiat JG, Finder CA. Sonography vs. excretory urography in acute flank pain. <i>AJR</i> 1985; 144(6):1235-1238.	Observational	61 patients	Prospective study to compare the diagnostic accuracy of US and excretory urography in acute flank pain.	Correct diagnosis made by urography in 85% and by US in 66%. Small stones at the ureterovesical junction were more accurately diagnosed by US (79%) than by urography (68%).	2
46. Laing FC, Jeffrey RB, Jr., Wing VW. Ultrasound versus excretory urography in evaluating acute flank pain. <i>Radiology</i> 1985; 154(3):613-616.	Review/Other	20 patients	Prospective study to compare US with excretory urography in acute flank pain.	US less useful than urography in acute flank pain.	4

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47. Svedstrom E, Alanen A, Nurmi M. Radiologic diagnosis of renal colic: the role of plain films, excretory urography and sonography. <i>Eur J Radiol</i> 1990; 11(3):180-183.	Observational	49 patients	Prospective study comparing roles of radiographs, excretory urography and US for the clinical work-up of renal colic for detecting urinary calculi.	Urography was most sensitive and specific test. Radiographs and US each had a sensitivity of approximately 60%, but combined yielded a sensitivity of 80%; specificity did not improve. Diagnostic algorithm where US was performed first followed by an excretory urography in case of a negative US was highly sensitive (93%) and specific (79%).	2
48. Platt JF, Rubin JM, Ellis JH. Acute renal obstruction: evaluation with intrarenal duplex Doppler and conventional US. <i>Radiology</i> 1993; 186(3):685-688.	Observational	23 patients	To evaluate the intrarenal renal duplex Doppler findings in acute obstruction and compare RI data to conventional US findings.	Mean RI in the obstructed kidneys was elevated (.77 ± .07 and higher than the mean RI in the normal contralateral kidney (.60 ± .04) (P<.001). Renal Duplex US gives useful clinical information especially when US is the first modality used for evaluation.	2
49. Rodgers PM, Bates JA, Irving HC. Intrarenal Doppler ultrasound studies in normal and acutely obstructed kidneys. <i>Br J Radiol</i> 1992; 65(771):207-212.	Observational	68 total patients, 48 with normal renal tracts and 20 with acute renal colic	A study on the differences between intrarenal Doppler findings in normal and obstructed kidneys.	RI of 14 obstructed kidneys (70.4 ± 6.22) was significantly higher than the mean RI of the 96 normal kidneys (62.4 ± 6.43). The mean difference between the RIs of the obstructed kidneys and their contralateral non-obstructed kidneys (8.37 ± 4.43) was also significantly higher than the differences in RI seen between pairs of normal kidneys (2.70 ± 1.71).	3
50. Fowler KA, Locken JA, Duchesne JH, Williamson MR. US for detecting renal calculi with nonenhanced CT as a reference standard. <i>Radiology</i> 2002; 222(1):109-113.	Observational	123 patients	To determine the sensitivity and specificity of US as compared to noncontrast CT for detection of renal parenchymal and collecting system calcifications.	Sensitivity and specificity of US for detection of renal calculi were 24% and 90%, respectively.	3
51. Ulasan S, Koc Z, Tokmak N. Accuracy of sonography for detecting renal stone: comparison with CT. <i>J Clin Ultrasound</i> 2007; 35(5):256-261.	Observational	50 patients	To determine the diagnostic accuracy of US for detection of urinary calculi as compared to noncontrast CT.	The overall accuracy of US for detection of a renal stone in the right kidney was 67%-77% and for detection of a renal stone in the left kidney was 53%-54%.	2
52. Dalla Palma L, Stacul F, Bazzocchi M, Pagnan L, Festini G, Marega D. Ultrasonography and plain film versus intravenous urography in ureteric colic. <i>Clin Radiol</i> 1993; 47(5):333-336.	Observational	180 patients	Prospective study to compare the use of initial IVU with US and radiograph in ureteric colic.	Radiographs plus US has sensitivity of 95%, specificity of 67% and NPV of 95%. Urography is recommended if radiograph plus US findings are equivocal or if intervention is necessary.	2
53. McAleer SJ, Loughlin KR. Nephrolithiasis and pregnancy. <i>Curr Opin Urol</i> 2004; 14(2):123-127.	Review/Other	N/A	To determine the most appropriate way to evaluate urinary calculus in pregnant women.	A combination of US and radiographs is recommended for pregnant patients.	4
54. Amis ES, Jr., Cronan JJ, Pfister RC, Yoder IC. Ultrasonic inaccuracies in diagnosing renal obstruction. <i>Urology</i> 1982; 19(1):101-105.	Review/Other	N/A	To review situations causing either false positive or negative renal sonograms.	To confirm or exclude obstruction, renal US should be followed with other diagnostic studies.	4

**Acute Onset Flank Pain — Suspicion of Stone Disease**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
55. Kamholtz RG, Cronan JJ, Dorfman GS. Obstruction and the minimally dilated renal collecting system: US evaluation. <i>Radiology</i> 1989; 170(1 Pt 1):51-53.	Review/Other	370 patients	Retrospective review to assess the significance of US demonstration of grade I hydronephrosis.	37/290 had grade I hydronephrosis. Obstruction was confirmed in two of the remaining 34 patients (6%). Incidental dilatation unlikely to represent obstruction.	4
56. Regan F, Bohlman ME, Khazan R, Rodriguez R, Schultze-Haakh H. MR urography using HASTE imaging in the assessment of ureteric obstruction. <i>AJR</i> 1996; 167(5):1115-1120.	Observational	56 patients	To prospectively evaluate the use of MRU using HASTE imaging in the assessment of ureteric obstruction.	HASTE MRU correctly diagnosed obstruction in 41 (100%) of 41 kidneys. Of the obstructed kidneys in which the ureter was shown by both excretory urography and MRU, agreement between the 2 techniques was high ( $\kappa=0.642$ ).	2
57. Zielonko J, Studniarek M, Markuszewski M. MR urography of obstructive uropathy: diagnostic value of the method in selected clinical groups. <i>Eur Radiol</i> 2003; 13(4):802-809.	Observational	60 patients	To evaluate the ability of MRU to define the degree of urinary tract dilatation as well as the site and type of obstruction.	There was an 85% concordance with other studies as to the degree of obstruction and a 92% concordance with the level of obstruction. MRU is superior among different clinical applications.	3
58. Roy C, Saussine C, LeBras Y, et al. Assessment of painful ureterohydronephrosis during pregnancy by MR urography. <i>Eur Radiol</i> 1996; 6(3):334-338.	Observational	17 patients	To evaluate RARE MRU in pregnant patients with acute flank pain.	MRU had 100% accuracy in detecting presence of obstruction and intrinsic vs extrinsic etiology, but not exact cause.	3
59. Thoeny HC, Kessler TM, Simon-Zoula S, et al. Renal oxygenation changes during acute unilateral ureteral obstruction: assessment with blood oxygen level-dependent mr imaging--initial experience. <i>Radiology</i> 2008; 247(3):754-761.	Observational	20 total patients, 10 male patients and 10 healthy male volunteers	To determine if changes in tissue oxygen levels can be depicted with blood oxygen level-dependent MRI.	Increased oxygen content was detected in the renal cortex and medulla in patients with acute unilateral ureteral obstruction.	3
60. Thoeny HC, Binser T, Roth B, Kessler TM, Vermathen P. Noninvasive assessment of acute ureteral obstruction with diffusion-weighted MR imaging: a prospective study. <i>Radiology</i> 2009; 252(3):721-728.	Observational	37 total patients: 21 patients and 16 controls	To prospectively assess the potential of noninvasive diffusion-weighted MRI to depict changes in microperfusion and diffusion in patients with acute unilateral ureteral obstruction.	Perfusion of the cortex of the obstructed kidney was significantly less than that of the nonobstructed kidney. No significant difference was seen in the ADC of the cortex or medulla in the obstructed as compared to the nonobstructed kidneys.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
61. Sudah M, Vanninen R, Partanen K, Heino A, Vainio P, Ala-Opas M. MR urography in evaluation of acute flank pain: T2-weighted sequences and gadolinium-enhanced three-dimensional FLASH compared with urography. Fast low-angle shot. <i>AJR</i> 2001; 176(1):105-112.	Observational	40 consecutive patients	Prospective study to compare the usefulness of breath-hold heavily T2-weighted sequences with gadolinium-enhanced 3D FLASH MRU in the evaluation of patients with acute flank pain. Excretory urography and the final clinical diagnosis used as reference.	26 patients had unilateral obstruction caused by ureteral stones. Both MRU methods were excellent for detecting obstruction. In the detection of stones, 3D FLASH was superior, with a sensitivity of 96.2% and 100% and specificity of 100% and 100% for observers A and B, respectively, compared with a sensitivity of 57.7% and 53.8% and a specificity of 100% and 100%, respectively, for T2-weighted sequences. The best degree of obstruction was seen with 3D FLASH, and the interobserver agreement was excellent for stone detection (kappa = 0.97). T2-weighted sequences alone are not sufficient for examining patients with acute flank pain. However, the combined use of both T2-weighted and 3D FLASH sequences will ensure better confidence in the evaluation of acute suspected renal colic. MRU can replace conventional excretory urography when the latter is contraindicated or undesirable.	2
62. Wieseler KM, Bhargava P, Kanal KM, Vaidya S, Stewart BK, Dighe MK. Imaging in pregnant patients: examination appropriateness. <i>Radiographics</i> 2010; 30(5):1215-1229; discussion 1230-1213.	Review/Other	N/A	Review examination appropriateness when imaging pregnant patients.	Modalities that do not use ionizing radiation, such as US and MRI, should be the preferred examinations for evaluating an acute condition in a pregnant patient. However, no examination should be withheld when an important clinical diagnosis is under consideration. Exposure to ionizing radiation may be unavoidable, but there is no evidence to suggest that the risk to the fetus after a single imaging study and an interventional procedure is significant. All efforts should be made to minimize the exposure, with consideration of the risk vs benefit for a given clinical scenario.	4

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**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
63. Rasmussen PE, Nielsen FR. Hydronephrosis during pregnancy: a literature survey. <i>Eur J Obstet Gynecol Reprod Biol</i> 1988; 27(3):249-259.	Review/Other	N/A	To review occurrence of hydronephrosis and hydroureters during pregnancy.	Conclusion is reached after survey of literature that there is every probability that hydronephrosis during pregnancy develops as a result of compression of the ureters between the pregnant uterus and the linea terminalis. It seems acute hydronephrosis or worsening of an existing hydronephrosis has been somewhat overlooked as a possible cause of uncertain abdominal pain during pregnancy. These conditions should be examined by means of US, and an attempt at treatment by a change in position should be made. In cases of continued pain or affected renal function, treatment should consist of the insertion of a ureteral catheter.	4
64. Stothers L, Lee LM. Renal colic in pregnancy. <i>J Urol</i> 1992; 148(5):1383-1387.	Observational	80 patients renal colic and pregnancy, 57 patients calculi	To review cases of renal colic occurring during pregnancy and present a scheme for managing renal calculi in pregnancy.	Most common symptom was flank pain seen in 89% of the patients, while greater than 95% displayed either microscopic or gross hematuria. Methods of radiographic diagnosis included US and limited stage excretory urography. Indications for urological or obstetrical intervention included persistent pain, sepsis, progressive hydronephrosis, solitary kidney or high grade obstruction. 37 procedures were done in 23 patients. The most common procedure was placement of a ureteral stent. The complication rate associated with intrapartum intervention and stent passage in the 23 patients was 16%. All patients with a ureteral stent subsequently had spontaneous vaginal delivery without complication.	3

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**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
65. Roy C, Saussine C, Jahn C, et al. Fast imaging MR assessment of ureterohydronephrosis during pregnancy. <i>Magn Reson Imaging</i> 1995; 13(6):767-772.	Observational	15 pregnant women	To assess the value of the fast imaging sequence called RARE-MRU for the diagnosis of pathologic ureterohydronephrosis during pregnancy. Results were compared with those of US, radiographs, and the evolution of symptoms.	The accuracy of RARE-MRU in the detection of urinary tract dilatation and the localization of the level of obstruction was excellent (100%). The determination of the type of obstruction, intrinsic vs extrinsic, was always exact. RARE-MRU alone cannot specify the exact nature of the intrinsic obstruction. US gave less sensitive information in terms of level (60%) and type of obstruction (53%). RARE-MRU is able to differentiate a physiological from a pathologic ureterohydronephrosis during pregnancy. It could be considered as a procedure of choice for special cases when US failed to establish this differential diagnosis.	2
66. 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. <i>J Urol</i> 2004; 171(6 Pt 1):2303-2306.	Observational	149 patients (110 had bilateral obstruction and 39 had obstruction of a solitary kidney), 259 renal units	Prospective study to compare the role of NCCT, MRU, and combined KUB and US in the diagnosis of the cause of ureteral obstruction in patients with compromised renal function. The gold standard included retrograde or antegrade ureterogram, ureteroscopy and/or open surgery.	The definitive cause of ureteral obstruction was calculous in 146 and noncalculous in 113 renal units. The site of stone impaction was identified by NCCT in all 146 renal units (100% sensitivity), by MRU in 101 (69.2% sensitivity), and by combined KUB and US in 115 (78.7% sensitivity). Ureteral strictures were identified by NCCT in 18/65 cases (28%) and by MRU in 54/65 (83%). Overall of the 113 kidneys with noncalculous obstruction the cause could be identified by MRU in 101 (89% sensitivity), by NCCT in 45 (40% sensitivity), and by combined KUB and US in only 20 (18% sensitivity) with a difference of significant value in favor of MRU ( $P<0.001$ ). In patients with renal impairment due to ureteral obstruction NCCT has superior diagnostic accuracy for detecting calculous causes of obstruction but MRU is superior for identifying noncalculous lesions.	3
67. Jaffe TA, Miller CM, Merkle EM. Practice patterns in imaging of the pregnant patient with abdominal pain: a survey of academic centers. <i>AJR</i> 2007; 189(5):1128-1134.	Review/Other	Survey sent to 183 radiology residency programs	To evaluate current practice patterns in the imaging of pregnant women with abdominal complaints.	85 surveys (46%) were returned. Most academic radiology departments have written policies regarding imaging of pregnant women. Academic radiologists prefer CT to MRI for imaging abdominal complaints in pregnant women, especially in the second and third trimesters.	4

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**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
68. Katz SI, Saluja S, Brink JA, Forman HP. Radiation dose associated with unenhanced CT for suspected renal colic: impact of repetitive studies. <i>AJR</i> 2006; 186(4):1120-1124.	Review/Other	5,564 studies in 4,562 patients	To assess the dose of ionizing radiation delivered through the use of unenhanced CT for suspected renal colic by determining the incidence of repeated unenhanced CT examinations and the cumulative radiation dose delivered.	176 patients had 3 or more CT with a radiation dose of 199.5 to 153.7 mSv. Patients with history of nephrolithiasis and flank pain are at increased risk for serial CT with potentially high cumulative effective doses.	4
69. Broder J, Bowen J, Lohr J, Babcock A, Yoon J. Cumulative CT exposures in emergency department patients evaluated for suspected renal colic. <i>J Emerg Med</i> 2007; 33(2):161-168.	Review/Other	356 patients	Retrospective review of CT in patients presenting to the emergency department to estimate the cumulative CT dose, diagnosis and outcome in these patients.	Patients are likely to undergo CT on multiple occasions. Radiation exposures from repeated CT scans are substantial.	4
70. American College of Radiology. <i>Manual on Contrast Media</i> . Available at: <a href="http://www.acr.org/SecondaryMainMenuCategories/quality_safety/contrast_manual.aspx">http://www.acr.org/SecondaryMainMenuCategories/quality_safety/contrast_manual.aspx</a> .	Review/Other	N/A	Guidance document on contrast media to assist radiologists in recognizing and managing risks associated with the use of contrast media.	N/A	4

## Evidence Table Key

### Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
  - a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
  - b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
  - c) the study is an expert opinion or consensus document.

## Abbreviations Key

CI = Confidence interval  
 CT = Computed tomography  
 FLASH = fast low-angle shot  
 HASTE = Half-Fourier acquisition single-shot turbo spin-echo  
 HCT = Helical computed tomography  
 IVU = Intravenous urography  
 KUB = Abdominal radiography  
 MDCT = Multidetector computed tomography  
 MRU = Magnetic resonance urography  
 NCCT = Noncontrast computed tomography  
 NPV = Negative predictive value  
 PPV = Positive predictive value  
 RARE = Rapid acquisition with relaxation enhancement  
 RI = Resistive index  
 US = Ultrasound