

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)**  
**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-Dx	121 patients had CT	Prospective observational study to evaluate use of HCT in first episode of suspected nephrolithiasis.	Four categories grouped the pre-CT diagnostic certainty: 0-49%, 50-74%, 75-90%, and 90-100%. The CT scan found urinary calculi in 28.6%, 45.7%, 74.2%, and 80.5% of patients in each category, respectively. CT scanning revealed alternate diagnoses in 40 cases (33.1%). Of these, 19 (47.5%) included other significant pathology. Before CT scanning, physicians planned to discharge 115 patients and admit six patients. After CT scanning, six of the former group were admitted, and five of the latter group were discharged. Patients presenting with a first episode of clinically suspected nephrolithiasis should undergo CT scanning because it enhances diagnostic certainty by identifying alternate diagnoses not suspected on clinical grounds.	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-Dx	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 2 primary treatment modalities for the management of symptomatic ureteral calculi.	4
3. Hyams ES, Korley FK, Pham JC, Matlaga BR. Trends in imaging use during the emergency department evaluation of flank pain. <i>J Urol.</i> 2011;186(6):2270-2274.	Review/Other-Dx	313,425 emergency department visits sampled between 2000 and 2008; 5,483 were for complaint of flank or kidney pain	To characterize the use of conventional radiography, US and CT in the emergency department evaluation of patients with acute flank pain.	During the study period there was a significant increase in CT use ( $P<0.0001$ ) and a significant decrease in x radiography use ( $P=0.035$ ) while US use remained stable ( $P=0.803$ ). During that period the proportion of patients with flank pain who were diagnosed with a kidney stone remained stable at approximately 20% ( $P=0.135$ ).	4
4. 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-Dx	20 patients	To compare NCCT and IVU in the evaluation of patients with acute flank pain.	2 techniques are equally effective in identification of obstruction; CT superior for identification of ureteric stones.	2

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5. 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 Am J Roentgenol.</i> 2002;178(1):101-103.	Observational-Dx	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
6. 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-Dx	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
7. 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 Am J Roentgenol.</i> 2009;192(6):1509-1513.	Observational-Dx	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 $\leq 5$ mm in diameter were improved with coronal reformations.	2
8. 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 Am J Roentgenol.</i> 2007;189(2):W60-64.	Observational-Dx	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
9. Berkovitz N, Simanovsky N, Katz R, Salama S, Hiller N. Coronal reconstruction of unenhanced abdominal CT for correct ureteral stone size classification. <i>Eur Radiol.</i> 2010;20(5):1047-1051.	Review/Other-Dx	151 stones in 150 patients	To determine whether size measurement of a urinary calculus in coronal reconstruction of CT differs from stone size measured in the axial plane, and whether the difference alters clinical decision making.	There were 151 stones in 150 patients (male:female 115:34, mean age 41 years). Transverse stone diameters ranged from 1 to 11 mm (mean 4 mm). On coronal images, 56 (37%) stones were upgraded in severity; 46 (30%) from below 5 mm to 6 mm or more, and 10 (7%) from 6–9 mm to 10 mm or more. Transverse measurement on the axial slices enabled correct categorization of 95 stones (63%).	4

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10. Eisner BH, Kambadakone A, Monga M, et al. Computerized tomography magnified bone windows are superior to standard soft tissue windows for accurate measurement of stone size: an in vitro and clinical study. <i>J Urol.</i> 2009;181(4):1710-1715.	Observational-Dx	24 urinary calculi	To determine the most accurate method of measuring urinary stones on CT.	In the in vitro portion of the study the most accurate measurements were obtained using 5.13x magnified bone windows with a mean 0.13 mm difference from caliper measurement ( $P=0.6$ ). Measurements performed in the soft tissue window with and without magnification, and in the bone window without magnification were significantly different from hand caliper measurements (mean difference 1.2, 1.9 and 1.4 mm, $P=0.003$ , $<0.001$ and $0.0002$ , respectively). When comparing measurement errors between stones of different composition in vitro, the error for calcium oxalate calculi was significantly different from the gold standard for all methods except bone window settings with magnification. For uric acid calculi the measurement error was observed only in standard soft tissue window settings. In vivo 4.0x magnified bone windows was superior to 4.0x magnified soft tissue windows in measurement accuracy. Magnified bone window measurements were not statistically different from digital caliper measurements (mean underestimation vs digital caliper 0.3 mm, $P=0.4$ ), while magnified soft tissue windows were statistically distinct (mean underestimation 1.4 mm, $P=0.001$ ).	3
11. Fracchia JA, Panagopoulos G, Katz RJ, Armenakas N, Sosa RE, DeCorato DR. Adequacy of low dose computed tomography in patients presenting with acute urinary colic. <i>J Endourol.</i> 2012;26(9):1242-1246.	Observational-Dx	101 consecutive adult patients	To determine adequacy of low dose CT in patients presenting with acute urinary colic.	Overall, 84 patients had an upper tract calculus(i) consistent with the clinical suspicion. Of these, 76 (90%) were adequately imaged with low-dose and 8 (10%) with conventional NCCTs. The mean effective radiation dose in the 76 low-dose stone-positive CTs was 2.14 mSv (median 2.10 mSv). This was almost seven-fold lower than the mean conventional stone-positive CT dose of 14.5 mSv (median 13.1 mSv).	2
12. 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-Dx	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

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13. Kulkarni NM, Uppot RN, Eisner BH, Sahani DV. Radiation dose reduction at multidetector CT with adaptive statistical iterative reconstruction for evaluation of urolithiasis: how low can we go? <i>Radiology</i> . 2012;265(1):158-166.	Observational-Dx	25 patients	To evaluate the performance of CT examinations at 80 and 100 kV with tube current-time products of 75-150 mA and the effect of adaptive statistical iterative reconstruction on CT image quality in patients with urinary stone disease.	Modified-protocol FBP images showed low image quality (score, 2.5), with improvement on modified-protocol adaptive statistical iterative reconstruction images (score, 3.4) ( $P=.03$ ). All 33 stones (mean diameter, 6.1 mm; range, 2–28 mm) at modified-protocol CT were diagnosed by both readers. In 20/25 patients (80%), adaptive statistical iterative reconstruction images were rated adequate for rendering other diagnoses in the abdomen (score, 2.0), as opposed to FBP images (score, 1.3). Mean radiation dose for modified-protocol CT was 1.8 mGy (1.3 mGy for patients <200 lb; 2.3 mGy for patients >200 lb) in comparison with 9.9 mGy for reference-protocol CT ( $P=.001$ ).	3
14. 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-Dx	50 patients	Prospective recruitment with retrospective review. To determine the accuracy of unenhanced HCT performed at reduced milliampere-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
15. Kalra MK, Maher MM, Toth TL, et al. Strategies for CT radiation dose optimization. <i>Radiology</i> . 2004;230(3):619-628.	Review/Other-Dx	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
16. 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-Dx	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 1 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
17. 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-Dx	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

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18. 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 Am J Roentgenol.</i> 2007;188(2):553-562.	Observational-Dx	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 2 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 2 reviewers, with kappa values of 0.98 for the low-dose and 0.96 for the standard-dose exams.	2
19. 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 Am J Roentgenol.</i> 2007;188(4):927-933.	Observational-Dx	125 patients	To compare a low-dose CT protocol with standard-dose unenhanced CT in patients with suspected renal colic.	Low-dose CT has sensitivities and specificities close to those of standard-dose CT. In patients with a body mass index of <30, low-dose CT achieved 96% sensitivity and 100% specificity for the detection of indirect signs of renal colic and a sensitivity of 95% and a specificity of 97% for detecting ureteral calculi. Low-dose CT was 86% sensitive for detecting ureteral calculi <3 mm and 100% sensitive for detecting calculi >3 mm.	2
20. Tack D, Sourtzis S, Delpierre I, de Maertelaer V, Gevenois PA. Low-dose unenhanced multidetector CT of patients with suspected renal colic. <i>AJR Am J Roentgenol.</i> 2003;180(2):305-311.	Observational-Dx	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
21. Jain N, Robinson S. Towards evidence based emergency medicine: best BETs from the Manchester Royal Infirmary. BET 4: Investigating flank pain: can the CT stay low? <i>Emerg Med J.</i> 2012;29(8):687-688.	Review/Other-Dx	7 papers	Review was performed to establish whether low dose CT can be used successfully in the diagnosis of renal tract disease in the emergency department.	280 papers were found using the reported search, of which 7 represent the best evidence to answer the clinical question. The author, date and country of publication, patient group studied, study type, relevant outcomes, results and study weaknesses of these best papers are tabulated. Unenhanced low-dose CT can be used effectively in the investigation of suspected renal colic.	4

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22. 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-Dx	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
23. Karmazyn B, Frush DP, Applegate KE, Maxfield C, Cohen MD, Jones RP. CT with a computer-simulated dose reduction technique for detection of pediatric nephroureterolithiasis: comparison of standard and reduced radiation doses. <i>AJR Am J Roentgenol</i> . 2009;192(1):143-149.	Observational-Dx	45 patients	To compare the diagnostic capabilities of standard- and reduced-dose CT in the detection of nephroureterolithiasis in children.	Compared with the standard tube current used for the original CT scans, there was no significant reduction ( $P=0.37$ ) in detection of renal stones at the 80-mA setting (mean dose reduction, 67%; range, 43%–81%); and at the 40-mA setting (mean dose reduction, 82%; range, 72%–90%), the detection rate was significantly lower ( $P=0.05$ ). At the 40-mA setting, there was no significant difference among the children weighing 50 kg or less ( $P=0.4$ ). Detection of ureteral stones and hydronephrosis was not significantly different at 80 and 40 mA; however, disease frequency was low, and no definite conclusion can be made.	2
24. Niemann T, Kollmann T, Bongartz G. Diagnostic performance of low-dose CT for the detection of urolithiasis: a meta-analysis. <i>AJR Am J Roentgenol</i> . 2008;191(2):396-401.	Meta-analysis	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.	M
25. 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-Dx	47 patients	To retrospectively determine the effect of 50% and 75% dose reduction on sensitivity and specificity of CT for the detection of urinary 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).	3

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26. Remer EM, Herts BR, Primak A, et al. Detection of Urolithiasis: Comparison of 100% Tube Exposure Images Reconstructed with Filtered Back Projection and 50% Tube Exposure Images Reconstructed with Sinogram-affirmed Iterative Reconstruction. <i>Radiology</i> . 2014;272(3):749-756.	Observational-Dx	99 patients	To compare images acquired with 50% tube exposure with a dual-source CT scanner and reconstructed with sinogram-affirmed iterative reconstruction with 100% exposure images reconstructed with FBP for reader ability to detect stones, reader confidence, and findings outside the urinary tract.	Calculi were found in 113 locations (pyelocalyceal ureter, 86; proximal ureter, 7; midureter, 4; distal ureter, 15; bladder, 1) and not found in 752 locations. Mean AUC for FBP was 0.879 (range, 0.607–0.967) and for sinogram-affirmed iterative reconstruction, 0.883 (range, 0.646–0.971; 95% CI: -0.025, 0.031). The sinogram-affirmed iterative reconstruction images were not significantly inferior to FBP images ( $P=.001$ ). Reader confidence levels for images with stones were similar with FBP and sinogram-affirmed iterative reconstruction ( $P=.963$ ). For the 52 patients who had extraordinary findings, readers reported them correctly in 74.4% (271/364) and 72.0% (262/364) of cases ( $P=.215$ ) for FBP and sinogram-affirmed iterative reconstruction, respectively. For the 9 patients with potentially important findings per the reference standard, the detection rates were 44% (28/63) and 33% (21/63, $P=.024$ ), respectively. For the 43 patients with unimportant or likely unimportant findings, the false detection rates were 15% (44/301) and 14% (43/301, $P=.756$ ), respectively.	3
27. Sohn W, Clayman RV, Lee JY, Cohen A, Mucksavage P. Low-dose and standard computed tomography scans yield equivalent stone measurements. <i>Urology</i> . 2013;81(2):231-234.	Observational-Dx	10 patients	To ascertain the reliability of low-dose CT compared with standard CT in the determination of stone size, density, and skin-to-stone distance.	No difference was found in stone size between the 2 dosage levels, as measured by the height, width, length, and volume of the stone ( $P=.9$ , $P=.7$ , $P=.8$ , and $P=.8$ respectively). In addition, no difference in HU was appreciated between the 2 scan types ( $P=.6$ ). Finally, no significant difference was found in the skin-to-stone distance ( $P=.5$ ). Between the 2 scans, the average effective dose reduction was 73%, from 23 to 6 mSv ( $P=.002$ ).	3
28. 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-Dx	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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29. 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 Am J Roentgenol.</i> 1997;168(4):997-1000.	Observational-Dx	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
30. Katz DS, Lane MJ, Sommer FG. Unenhanced helical CT of ureteral stones: incidence of associated urinary tract findings. <i>AJR Am J Roentgenol.</i> 1996;166(6):1319-1322.	Review/Other-Dx	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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31. Smith RC, Verga M, Dalrymple N, McCarthy S, Rosenfield AT. Acute ureteral obstruction: value of secondary signs of helical unenhanced CT. <i>AJR Am J Roentgenol.</i> 1996;167(5):1109-1113.	Observational-Dx	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
32. 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-Dx	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
33. 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-Dx	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
34. Smith RC, Verga M, McCarthy S, Rosenfield AT. Diagnosis of acute flank pain: value of unenhanced helical CT. <i>AJR Am J Roentgenol.</i> 1996;166(1):97-101.	Observational-Dx	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
35. 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-Dx	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

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36. Dym RJ, Duncan DR, Spektor M, Cohen HW, Scheinfeld MH. Renal stones on portal venous phase contrast-enhanced CT: does intravenous contrast interfere with detection? <i>Abdom Imaging</i> . 2014;39(3):526-532.	Observational-Dx	97 CT exams	To determine the sensitivity of portal venous phase contrast-enhanced CT for the detection of renal stones.	The 97 cases included a total of 238 stones $\geq 1$ mm, with a mean (+/-SD) of 1.2 +/- 1.9 stones per kidney and a stone diameter of 3.5 +/- 3.0 mm. Pooling data for the 3 reviewers, sensitivity for all stones was 81%; sensitivity for stones $\geq 2$ , $\geq 3$ , $\geq 4$ , and $\geq 5$ mm was 88%, 95%, 99%, and 98%, respectively. Sensitivity for stone disease on a per-kidney basis was 94% when considering all stones; when considering only stones $\geq 2$ , $\geq 3$ , and $\geq 4$ mm, sensitivity was 96%, 99%, and 100%, respectively. Specificity for stone disease on a per-kidney basis was 98% overall, 99% when considering only stones $\geq 2$ mm, and 100% when considering only stones $\geq 3$ mm.	3
37. Eiber M, Holzapfel K, Frimberger M, et al. Targeted dual-energy single-source CT for characterisation of urinary calculi: experimental and clinical experience. <i>Eur Radiol</i> . 2012;22(1):251-258.	Observational-Dx	46 patients	To assess the accuracy of targeted dual-energy single-source MDCT for characterization of urinary calculi.	In 26/46 patients no misregistration was present. Mean deviations were 2.7 mm in the z-axis (16 patients) and 4.3 mm in the axial plane (10 patients). The dual-energy-indices were 0.018 +/- 0.016 for UA, 0.035 +/- 0.015 for mixed UA and 0.102 +/- 0.015 for calcified stones in-vitro and 0.017 +/- 0.002 for UA, 0.050 +/- 0.019 for mixed UA and 0.122 +/- 0.024 for calcified calculi in-vivo. Significant differences were noted among calcium, mixed UA and UA stones ( $P < 0.05$ ). For the low-dose examination mean effective dose was 3.11 mSv. Targeted dual-energy resulted in an extra dose of 1.84 mSv (additional 59.1%).	3

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38. Fung GS, Kawamoto S, Matlaga BR, et al. Differentiation of kidney stones using dual-energy CT with and without a tin filter. <i>AJR Am J Roentgenol.</i> 2012;198(6):1380-1386.	Review/Other-Dx	48 human kidney stone samples	To examine the capability of 3 protocols of dual-energy CT imaging in distinguishing calcium oxalate, calcium phosphate, and UA kidney stones.	For all 3 protocols, the UA stones were significantly different ( $P<0.001$ ) from the calciferous stones according to their dual-energy ratio values. For differentiating calcium oxalate and calcium phosphate stones, the difference between their dual-energy ratio values was statistically significant, with different degrees of significance (range, $P<0.001$ to $P=0.03$ ) for all 3 protocols. On the basis of the values of the AUC of calcified stone differentiation, the 3 protocols were ranked in the following order: the 80- and 140-kVp tin filter protocol (AUC, 0.996), the 100- and 140-kVp tin filter protocol (AUC, 0.918), and the 80- and 140-kVp protocol (AUC, 0.871).	4
39. Kulkarni NM, Eisner BH, Pinho DF, Joshi MC, Kambadakone AR, Sahani DV. Determination of renal stone composition in phantom and patients using single-source dual-energy computed tomography. <i>J Comput Assist Tomogr.</i> 2013;37(1):37-45.	Observational-Dx	45 patients	To characterize the urinary tract stones in phantom and patients using single-source dual-energy CT.	Of the 59 verified stones (phantom, 20; patients, 39; mean size, 6 mm), there were 16 UA and 43 non-UA type. The material density images were 100% sensitive and accurate in detecting UA and non-UA stones. The Zeff accurately stratified struvite, cystine, and calcium (calcium oxalate monohydrate) stones in the phantom. In patients, Zeff identified 83% of calcium stones (n = 24), and in stones of mixed type, it resembled dominant composition. The HU measurements alone were 71% sensitive and 69% accurate in detecting the UA stones.	3

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
40. Li X, Zhao R, Liu B, Yu Y. Gemstone spectral imaging dual-energy computed tomography: a novel technique to determine urinary stone composition. <i>Urology</i> . 2013;81(4):727-730.	Review/Other-Dx	116 urinary stones	To assess the capability of determining the chemical composition of urinary stones using dual-energy spectral CT.	The 116 urinary stones were classified into 7 groups: UA (n = 16), cystine (n = 10), brushite (n = 17), weddellite (n = 14), whewellite (n = 24), carbapatite (n = 12), and struvite (n = 23). The paired CT numbers (at 120 kVp and 50 keV, respectively) of each stone group were as follows: UA, 469.11 +/- 69.83 and 474.06 +/- 40.55 HU; cystine, 564.81 +/- 97.71 and 839.58 +/- 92.14 HU; brushite, 1830.94 +/- 59.19 and 2787.41 +/- 306.07 HU; weddellite, 1438.09 +/- 191.12 and 2100.79 +/- 202.32 HU; whewellite, 1493.48 +/- 259.90 and 2321.39 +/- 367.23 HU; carbapatite, 1784.58 +/- 106.42 and 2513.86 +/- 189.09 HU; and struvite, 833.037 +/- 9.91 and 1123.24 +/- 267.70 HU. The differences in the CT numbers at 120 kVp and 50 keV among the groups were statistically significant by binary comparison ( $P < .05$ ), except for those at 120 kVp between UA and cystine ( $P = .121$ ), whewellite and weddellite ( $P = .280$ ), and brushite and carbapatite ( $P = .419$ ).	4
41. 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-Dx	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
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 Am J Roentgenol</i> . 2008;190(3):720-728.	Observational-Dx	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

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
43. Mangold S, Thomas C, Fenchel M, et al. Virtual nonenhanced dual-energy CT urography with tin-filter technology: determinants of detection of urinary calculi in the renal collecting system. <i>Radiology</i> . 2012;264(1):119-125.	Observational-Dx	152 patients	To retrospectively determine which features of urinary calculi are associated with their detection after virtual elimination of contrast medium at dual-energy CT urography by using a novel tin filter.	87 stones were detected on true nonenhanced images; 46 calculi were identified on virtual nonenhanced images (sensitivity, 52.9%). Inter-rater agreement revealed a kappa value of 0.95 with true nonenhanced images and 0.91 with virtual nonenhanced data. Size (long-axis diameter, $P=.005$ ; short-axis diameter, $P=.041$ ) and attenuation ( $P=.0005$ ) of the calculi and image noise ( $P=.0031$ ) were significantly associated with the detection rate on virtual nonenhanced images. As threshold values, size $>2.9$ mm, maximum attenuation of the calculi $>387$ HU, and image noise $<20$ HU were found.	2
44. Moon JW, Park BK, Kim CK, Park SY. Evaluation of virtual unenhanced CT obtained from dual-energy CT urography for detecting urinary stones. <i>Br J Radiol</i> . 2012;85(1014):e176-181.	Observational-Dx	146 patients	To determine if virtual unenhanced CT is equivalent to unenhanced CT for detecting urinary stones.	62 stones in 29 patients were detected on nephrographic virtual unenhanced CT and 59 stones in 27 patients were detected on excretory virtual unenhanced CT. The size of stones detected on nephrographic virtual unenhanced CT or excretory virtual unenhanced CT was significantly smaller compared with stones on unenhanced CT ( $P<0.05$ ). The size of stones detected on unenhanced CT, nephrographic virtual unenhanced CT and excretory virtual unenhanced CT ranged from 1.4 to 19.2 mm (mean, 4.6 mm), 0 to 19.2 mm (mean, 3.6 mm) and 0 to 18.7 mm (mean, 3.6 mm), respectively. 18 stones were missed on nephrographic virtual unenhanced CT and 21 were missed on excretory virtual unenhanced CT. The sizes ranged from 1.4 to 3.2 mm (mean, 2.1 mm) and 1.4 to 3.2 mm (mean, 2.2 mm) on unenhanced CT, respectively. Virtual unenhanced CT was inferior to unenhanced CT regarding image quality ( $P<0.05$ ).	3

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
45. Jung SI, Kim YJ, Park HS, et al. Sensitivity of digital abdominal radiography for the detection of ureter stones by stone size and location. <i>J Comput Assist Tomogr.</i> 2010;34(6):879-882.	Observational-Dx	163 patients	To assess the sensitivity of digital KUB in the detection of ureteral stones by stone size and location.	In 163 ureteral stones, 77 stones (47.2%) were in the proximal ureter and 86 stones (52.8%) were in the distal ureter. The mean (SD) size of the ureteral stones was 3.4 (1.7) mm (range, 1–9 mm). Overall sensitivity of digital radiography for ureteral stones was 29.4%. The sensitivity of digital radiography for the proximal ureteral stones was 37.7% and that for the distal ureteral stones was 22.1% ( $P<0.05$ ). The sensitivity of digital radiography for small ureteral stones was 23.6% and that for large ureteral stones was 50.0% ( $P<0.05$ ). As a group, the sensitivity of digital radiography for large proximal ureteral stones was the highest sensitivity-72.2% in all groups ( $P<0.05$ ).	2
46. 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-Dx	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
47. Ripolles T, Martinez-Perez MJ, Vizuete J, Miralles S, Delgado F, Pastor-Navarro T. Sonographic diagnosis of symptomatic ureteral calculi: usefulness of the twinkling artifact. <i>Abdom Imaging.</i> 2013;38(4):863-869.	Observational-Dx	100 patients	To analyze the value of US using the twinkling sign in the diagnosis of ureteral stones in patients with renal colic in the emergency setting.	US including color Doppler detected 76 of the 84 confirmed lithiasis. The sensitivity and specificity were 90% and 100%, respectively. The PPV was 100% and the NPV 67%. The accuracy was 92%. A total of 59 calculi (78%) examined by color Doppler US showed the twinkling artifact. 70% of the twinkling-positive calculi showed the artifact before the stone itself was detected. Considering the location of the stones the twinkling sign was seen before the stone in 92% of lithiasis located in the mid lumbar ureter ( $P=0.02$ ). The use of the twinkling artifact showed a trend to facilitate the detection of smaller calculi (<10 mm) ( $P=0.08$ ). The average examination time was 5.8 min [ $\pm$ 4.3] (without differences between the stones detected before or after the twinkling artifact, $P=0.75$ ).	3

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
48. Sheafor DH, Hertzberg BS, Freed KS, et al. Nonenhanced helical CT and US in the emergency evaluation of patients with renal colic: prospective comparison. <i>Radiology</i> . 2000;217(3):792-797.	Observational-Dx	45 patients	Prospective comparison of nonenhanced helical CT and US for the depiction of urolithiasis.	Diagnoses included 23 ureteral calculi and 1 each of renal cell carcinoma, appendicitis, ureteropelvic junction obstruction, renal subcapsular hematoma, cholelithiasis, medullary calcinosis, and myelolipoma. CT depicted 22/23 ureteral calculi (sensitivity, 96%). US depicted 14/23 ureteral calculi (sensitivity, 61%). Differences in sensitivity were statistically significant (P=.02). Specificity for each technique was 100%. When modalities were compared for the detection of any clinically relevant abnormality (eg, unilateral hydronephrosis and/or urolithiasis in patients with an obstructing calculus), sensitivities of US and CT increased to 92% and 100%, respectively. One case of appendicitis was missed at US, whereas medullary calcinosis and myelolipoma were missed at CT.	1
49. Kielar AZ, Shabana W, Vakili M, Rubin J. Prospective evaluation of Doppler sonography to detect the twinkling artifact versus unenhanced computed tomography for identifying urinary tract calculi. <i>J Ultrasound Med</i> . 2012;31(10):1619-1625.	Observational-Dx	51 patients	To evaluate the diagnostic accuracy of the twinkling artifact compared to unenhanced CT in detecting urolithiasis.	There were 35 right-sided and 38 left-sided renal calculi, 14 right-sided and 21 left-sided ureteric calculi, and 6 bladder calculi (total, 114 calculi). 13 patients had no calculi. The average calculus size was 2.6 mm (range, 1–9 mm). There were 6 false-positive and 22 false-negative instances of twinkling artifacts. On gray-scale evaluation looking for an echogenic focus with shadowing, there were 8 false-positive and 40 false-negative findings. The PPV of the twinkling artifact for identifying calculi was 94%, and the sensitivity was 83%. The PPV of gray-scale sonographic shadowing was only 64.9%, and the sensitivity was 80.2%.	2
50. Rahmouni A, Bargoin R, Herment A, Bargoin N, Vasile N. Color Doppler twinkling artifact in hyperechoic regions. <i>Radiology</i> . 1996;199(1):269-271.	Review/Other-Dx	140 patients	To investigate a new color Doppler US artifact that manifested as a rapidly changing mixture of red and blue behind a strongly reflecting structure.	The artifact was found in 42 parenchymal calcifications. In vitro experiments showed that the twinkling artifact was present in granular structures, whereas no color signal was noted in smooth surfaces. The "twinkling sign" appeared to be generated by a strongly reflecting medium composed of individual reflectors.	4

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
51. 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-Dx	123 patients	To determine the sensitivity and specificity of US as compared to NCCT 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
52. 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-Dx	50 patients	To determine accuracy of US in the detection of renal stones using noncontrast CT as the gold standard.	The sensitivity of sonography for any stone in a patient was 52-57% for the right kidney (radiologist 1 and 2) and 32-39% for the left kidney (radiologist 1 and 2). The overall accuracy of sonography in detecting a stone in the right kidney by radiologists 1 and 2 was 67% and 77%, respectively. The corresponding accuracy values for the left kidney were 53% and 54%, respectively.	2
53. 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-Dx	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
54. 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 Am J Roentgenol</i> . 2001;177(2):325-330.	Review/Other-Dx	227 patients	To investigate the relationship between duration of flank pain and the frequency of secondary signs of ureteral obstruction on unenhanced HCT.	The frequency of moderate or severe perinephric stranding increased from 5% at 1–2 hours to 51% at 7–8 hours ( $P<0.001$ ); ureteral dilatation increased from 84% at 1–2 hours to 97% at more than 8 hours ( $P<0.03$ ); moderate or severe perinephric fluid increased from 0% at 1–2 hours to 22% at 3–4 hours ( $P<0.03$ ); collecting system dilatation increased from 68% at 1–2 hours to 89% at 7–8 hours ( $P<0.03$ ); periureteral stranding increased from 35% at 1–2 hours to 76% at 7–8 hours ( $P<0.004$ ); and nephromegaly increased from 40% at 1–2 hours to 54% at 7–8 hours ( $P<0.36$ ).	4



Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)  
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
55. Smith-Bindman R, Aubin C, Bailitz J, et al. Ultrasonography versus computed tomography for suspected nephrolithiasis. <i>N Engl J Med.</i> 2014;371(12):1100-1110.	Experimental-Dx	2,759 patients	To assess the effect of diagnostic imaging techniques on patient outcomes in a multicenter, randomized trial comparing US with CT.	A total of 2,759 patients underwent randomization: 908 to point-of-care US, 893 to radiology US, and 958 to CT. The incidence of high-risk diagnoses with complications in the first 30 days was low (0.4%) and did not vary according to imaging method. The mean 6-month cumulative radiation exposure was significantly lower in the US groups than in the CT group ( $P<0.001$ ). Serious adverse events occurred in 12.4% of the patients assigned to point-of-care US, 10.8% of those assigned to radiology US, and 11.2% of those assigned to CT ( $P=0.50$ ). Related adverse events were infrequent (incidence, 0.4%) and similar across groups. By 7 days, the average pain score was 2.0 in each group ( $P=0.84$ ). Return emergency department visits, hospitalizations, and diagnostic accuracy did not differ significantly among the groups.	1
56. Ekici S, Sinanoglu O. Comparison of conventional radiography combined with ultrasonography versus nonenhanced helical computed tomography in evaluation of patients with renal colic. <i>Urol Res.</i> 2012;40(5):543-547.	Observational-Dx	300 patients	To evaluate the diagnostic accuracy of combined use of KUB and US vs nonenhanced CT in renal and ureteral stones and to discuss the findings.	Of patients with negative findings on KUB and/or US, 22 had renal stones on nonenhanced CT (mean size 4.4 mm, range 3–8), 3 had lower ureteral stone (mean size 3.3 mm, range 2–5). In patients with isolated suspicious renal ectasia without stone image, 2 had renal stone on nonenhanced CT (mean size 4 mm, range 2–6), 5 had upper ureteral stone (mean size 4.4 mm, range 4–6), 7 had middle ureteral stone (mean size 3.7 mm, range 3–4) and 14 had lower ureteral stone (mean size 4 mm, range 2–6). The cost-effective and almost radiation-free combination of KUB and US should be preferred for diagnosis of urolithiasis, as it detects most of the ureteral and renal calculi which are clinically significant.	3
57. 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-Dx	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 (Urolithiasis)**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
58. 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-Dx	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 2 of the remaining 34 patients (6%). Incidental dilatation unlikely to represent obstruction.	4
59. Kalb B, Sharma P, Salman K, Ogan K, Pattaras JG, Martin DR. Acute abdominal pain: is there a potential role for MRI in the setting of the emergency department in a patient with renal calculi? <i>J Magn Reson Imaging</i> . 2010;32(5):1012-1023.	Review/Other-Dx	N/A	To describe the potential utility and limitations of MRI in the emergency setting for diagnosing causes of flank pain and renal colic, particularly in patients with unusual presentations or when an alternative to CT may be warranted.	No results stated in abstract.	4
60. Semins MJ, Feng Z, Trock B, Bohlman M, Hosek W, Matlaga BR. Evaluation of acute renal colic: a comparison of non-contrast CT versus 3-T non-contrast HASTE MR urography. <i>Urolithiasis</i> . 2013;41(1):43-46.	Observational-Dx	22 patients	Prospective study was performed to compare the performance of CT with HASTE MRU in the evaluation of patients with suspected renal colic.	20 (91 %) were diagnosed with an upper tract stone by radiographic findings. MRU detected a discrete stone in 50% of the patients with stones detected by CT. Perinephric fluid was noted in 12 MRUs, compared to 7 CTs. Using CT as the reference standard, the combination of stone or perinephric fluid and ureteral dilation gave MRU a sensitivity of 84%, specificity of 100%, and accuracy of 86% (95% CI, 0.72–1.0). HASTE MRU with a 3-T MR scanner can reliably detect the presence of upper urinary tract obstruction. Although CT imaging remains the superior modality with which to detect calculi, MRU detects a greater number of secondary signs of upper tract obstruction. For situations in which the use of ionizing radiation is undesirable, MRU is a reasonable imaging alternative.	3
61. Regan F, Bohlman ME, Khazan R, Rodriguez R, Schultze-Haakh H. MR urography using HASTE imaging in the assessment of ureteric obstruction. <i>AJR Am J Roentgenol</i> . 1996;167(5):1115-1120.	Observational-Dx	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
62. 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-Dx	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

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
63. Yassin A, Pedrosa I, Kearney M, Genega E, Rofsky NM, Lenkinski RE. In vitro MR imaging of renal stones with an ultra-short echo time magnetic resonance imaging sequence. <i>Acad Radiol</i> . 2012;19(12):1566-1572.	Review/Other-Dx	36 patients	To characterize the MR relaxation times (ie, T1 and T2 relaxation times) of a variety of kidney stone specimens using an ultra-short echo time sequence and to correlate these values to their size and composition based on chemical analysis.	The average stone size was 0.86 cm (range 0.1–3.3 cm). 21 stones were visible by MR. The average size of MR-visible stones was 1.1 cm (range 0.15–3.3 cm) compared to 0.46 cm (range 0.1–0.9) for nonvisible stones. The mean T1 and T2 of MR-visible stones were 950 ms (range 138–3000 ms) and 3.12 ms (range 0.27–12 ms), respectively. The T1 (mean 1143, range 740–1583) and T1 (mean 8.31, range 4.6–12) values of calcium phosphate were longer than that for other stone compositions T1 (mean 953, range 138–3000) and T2 (mean 2.58, range 0.27–5.8; $P<0.05$ ).	4
64. 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-Dx	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
65. Thoeny HC, Binsler 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-Dx	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

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
66. 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 Am J Roentgenol.</i> 2001;176(1):105-112.	Observational-Dx	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
67. 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 Am J Roentgenol.</i> 2000;175(6):1689-1695.	Observational-Dx	93 patients	Prospective study to evaluate the impact of unenhanced CT on clinician diagnostic confidence and therapeutic efficacy in patients with suspected renal colic.	Fifty-six patients (60%) had positive findings for calculi, 20 patients (22%) had normal findings, and alternative diagnoses were found in 17 patients (18%). The clinician's diagnostic certainty of stones before CT was variable with the largest frequencies at 41-60% (n = 30) and 71-90% (n = 35). The diagnostic certainty of stones after CT showed movement toward either less than or equal to 10% (n = 25) or greater than or equal to 91% (n = 51). The mean change in diagnostic confidence was 34%. Fifty-seven patients (61%) had a change in treatment plan. Specifically, the need for urology consultation as the initial treatment plan was reduced from 24 patients to one patient. Plans for admissions suggested before CT (n = 11) were nearly cut in half (n = 6) after imaging. Lastly, seven patients who would have initially been discharged were admitted to the hospital after imaging.	3

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)  
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 Am J Roentgenol.</i> 2006;186(4):1120-1124.	Review/Other-Dx	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-Dx	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. Sfoungaristos S, Gofrit ON, Katz R, et al. A predictive model for stone radiopacity in kidney-ureter-bladder film based on computed tomography parameters. <i>Urology.</i> 2014;84(5):1021-1025.	Observational-Dx	375 patients	To create a model for prediction of stone radiopacity based on CT parameters.	Of 375 patients who met inclusion criteria and were finally analyzed, all 206 visible stones in scout film were KUB radiopaque. Analyzing scout-negative stones, the authors found that 92 stones (54.4%) were radiopaque in KUB. Multivariate analysis showed that stone size >9.7 mm, non-midureteral stone location, anterior abdominal wall fat thickness ≤23.9 mm, and Hounsfield units >772 are all independent predictors of stone radiopacity in stones that were not visible in scout film, and the aforementioned parameters were used for the creation of a Web-based calculator.	3
71. 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-Dx	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

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
72. Masselli G, Derme M, Laghi F, et al. Imaging of stone disease in pregnancy. <i>Abdom Imaging</i> . 2013;38(6):1409-1414.	Review/Other-Dx	N/A	To review imaging of renal colic in pregnant women.	US is widely used as the first-line diagnostic test in pregnant women with nephrolithiasis, despite it is highly nonspecific and may be unable to differentiate between ureteral obstruction secondary to calculi and physiologic hydronephrosis. MRI should be considered as a second-line test, when US fails to establish a diagnosis and there are continued symptoms despite conservative management.	4
73. McAleer SJ, Loughlin KR. Nephrolithiasis and pregnancy. <i>Curr Opin Urol</i> . 2004;14(2):123-127.	Review/Other-Dx	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
74. 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-Dx	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

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
75. 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.	Review/Other-Dx	20 patients	The authors report their institution's experience using low-dose CT in the evaluation of pregnant patients with refractory flank pain.	Between April 2004 and December 2006, 20 patients with an average gestational age of 26.5 weeks presented to our institution with acute, refractory flank pain consistent with a diagnosis of urolithiasis. All patients underwent renal US evaluation before unenhanced CT of the abdomen and pelvis using a low-dose protocol. The average radiation exposure was 705.75 mrad (range 210–1372; SD +/- 338.66 mrad). Of the 20 patients, CT demonstrated urinary stones (1–12 mm) in 13. Of those patients with documented stones, 4 were treated conservatively, 2 underwent intrapartum stent placement, 5 had ureteroscopy with stone extraction, and 2 were treated postpartum.	4
76. 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-Dx	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

**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
77. 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-Dx	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
78. Jaffe TA, Miller CM, Merkle EM. Practice patterns in imaging of the pregnant patient with abdominal pain: a survey of academic centers. <i>AJR Am J Roentgenol.</i> 2007;189(5):1128-1134.	Review/Other-Dx	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
79. American College of Radiology. ACR-SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation. Available at: <a href="http://www.acr.org/~media/ACR/Documents/PGTS/guidelines/Pregnant_Patients.pdf">http://www.acr.org/~media/ACR/Documents/PGTS/guidelines/Pregnant_Patients.pdf</a> . Accessed September 30, 2015.	Review/Other-Dx	N/A	Guidance document to promote the safe and effective use of diagnostic and therapeutic radiology by describing specific training, skills and techniques.	N/A	4
80. American College of Radiology. ACR-ACOG-AIUM-SRU Practice Parameter for the Performance of Obstetrical Ultrasound. Available at: <a href="http://www.acr.org/~media/ACR/Documents/PGTS/guidelines/US_Obstetrical.pdf">http://www.acr.org/~media/ACR/Documents/PGTS/guidelines/US_Obstetrical.pdf</a> . Accessed September 30, 2015.	Review/Other-Dx	N/A	Guidance document to promote the safe and effective use of diagnostic and therapeutic radiology by describing specific training, skills and techniques.	N/A	4



**Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
81. Kanal E, Barkovich AJ, Bell C, et al. ACR guidance document on MR safe practices: 2013. <i>J Magn Reson Imaging</i> . 2013;37(3):501-530.	Review/Other-Dx	N/A	Guidance document on MR safety practices to help guide MR practitioners regarding MR safety issues and provide a basis for them to develop and implement their own MR policies and practices.	N/A	4
82. American College of Radiology. <i>Manual on Contrast Media</i> . Available at: <a href="http://www.acr.org/~media/37D84428BF1D4E1B9A3A2918DA9E27A3.pdf">http://www.acr.org/~media/37D84428BF1D4E1B9A3A2918DA9E27A3.pdf</a> . Accessed September 30, 2015.	Review/Other-Dx	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.
- M = Meta-analysis

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Dx = Diagnostic

Tx = Treatment

## Abbreviations Key

AUC = Area under receiver operating characteristic curve  
CI = Confidence interval  
CT = Computed tomography  
FBP = Filtered back projection  
FLASH = Fast low-angle shot  
HASTE = Half-Fourier acquisition single-shot turbo spin-echo  
HCT = Helical computed tomography  
HU = Hounsfield units  
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  
UA = Uric acid  
US = Ultrasound