Evidence Report for Imaging in the Management of Ureteral Calculous Disease

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Introduction

This document is an evidence report intended to provide the expert panel with a review and synthesis of results from a comprehensive literature search on the imaging of ureteral calculi. The overall objective of this work is to assist the panel in defining the most appropriate imaging modalities for patients with suspected or known ureteral calculi or for patients undergoing follow-up.

Key Questions

To assist in the development of pertinent AUA guidelines for the stated objective, the panel created three general key questions and 14 specific questions within the topic refinement document (see Appendix A). To facilitate the literature review, these questions were reorganized into 31 Guiding Questions (GQs) classified by index patient, specific modality, and other factors (see Appendix B). This set of questions was translated into a PubMed strategy for the literature search.

Methods

Literature Search

A comprehensive search of the literature related to the Guiding Questions was performed by the ECRI Institute. Searches included articles published between January 1990 and July 2011, and were targeted toward major subtopics associated with imaging of ureteral calculi including: unenhanced (non-contrast) computed tomography (CT), conventional radiography (X-ray), ultrasound (US), intravenous pyelography (IVP), magnetic resonance imaging (MRI), nuclear medicine (NM) studies, hydronephrosis, extravasation, and follow-up imaging. Strategies for each respective search are detailed in Supplementary Table 1, Appendix C.

Study Selection after Literature Search

The methodologist reviewed all non-redundant abstracts identified in the literature search. Studies that potentially fulfilled the outlined inclusion criteria (below) were selected for full text retrieval. A spreadsheet was used to track included and excluded articles. Each title and abstract was coded initially with "**E**" for exclude or "**R**" for retrieved. Abstracts designated for full text retrieval were also assigned codes based on topics they were related to. After reviewing each full text article, the methodologist or one of two other extractors coded the article as "**I**" for include or "**E**" for exclude. Excluded articles were further denoted with a code representing the reason for exclusion.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria considered during the abstract and full text review are outlined below.

Population

Included: Patients satisfying one or more of the four following scenarios: (i) primary flank pain or renal colic with no previous history of stone, (ii) flank pain with known history of renal calculus disease, (iii) follow-up of known ureteral stone, (iv) follow-up after treatment of ureteral stone.

An age threshold of 14 years was selected for separating pediatric and adult patient populations. This threshold was determined after initial assessment of the available literature and recommendations by the panel. The methodologist collected articles that focused on the pediatric population for separate assessment. Given the lack of gender specific studies retrieved, the methodologist did not distinguish between male and female patients, with the exception of pregnant female patients, who were assessed independently.

Excluded: Patients representing unique and infrequent challenges for imaging modalities e.g. morbidly obese subjects, patients with anatomical abnormalities that preclude standard imaging techniques.

Interventions

Included: non-contrast computed tomography (CT), conventional radiography (X-ray), intravenous pyelography (IVP), ultrasound (US), magnetic resonance imaging (MRI), nuclear medicine (NM), or any combination of the above.

Excluded: All other imaging techniques were excluded.

Settings

Included: All settings where such tests are routinely used were included.

Excluded: Studies performed in atypical settings e.g. remote natural areas, settings with limited access to electricity, water, or appropriate medical staff and practices.

Study design

Given the diagnostic nature of the topic and the unknown size of the body of literature, there were no restrictions on study design. Included studies were randomized controlled trials (RCTs); controlled clinical trials (CCTs); observational studies including: cohort studies with and without comparison group, case-control studies, case series, as well as more general prospective and retrospective diagnostic accuracy studies.

Excluded: Studies of non-living humans, animals, or artificial systems.

Sample size

Studies with less than 10 patients were excluded from data extraction given the unreliability of the statistical estimates that can be derived from them.

Follow-up

All follow-up lengths available were examined.

Language of publication

Included: English-language publications were included.

Excluded: Publications in all other languages were excluded.

Publication type

Included: Studies with full text publication available were included.

Excluded: Studies published only as abstracts were excluded.

Classification of Articles

Articles were classified according to several factors including: study design, sample size, index patient scenario, general patient characteristics, imaging modalities, and related key and specific questions.

Data Extraction/Abstraction

Articles included for full text review were extracted separately by the methodologist and two additional extractors (all contractors) using a standardized extraction Excel workbook. The methodologist developed the forms and trained the extractors. Given the large number of articles to be examined, independent double extraction was not possible for most of the studies. Instead, the methodologist reviewed the work of the other extractors and searched for inconsistencies and missing information in the extracted data.

Assessment of Study Quality

For questions related to imaging diagnosis that utilized the non-contrast CT as the "reference standard", the QUADAS tool (Whiting et al. 2003), which evaluates the quality for diagnostic procedures, was used. See Appendix E for the full instrument. For questions in which this is not the case, the following quality instruments were applied:

1. RCTs and CCTs: the criteria of Higgins et al. (2007) for Risk of Bias (the Cochrane Collaboration's instrument). See Appendix X for the full instrument.

2. Observational studies:

a. For case-control studies/cohort with comparison group: Newcastle-Ottawa scale (Wells et al. 1999). See Appendix X for the full instrument.

b. For cohort studies without a comparison group (including pre vs. post studies and case series) and diagnostic studies in which CT was not the reference standard: no formal quality assessment was performed.

Analyses

A separate analysis was conducted for each Guiding Question in which at least one relevant study met the inclusion criteria. A qualitative assessment of all included studies was performed, including examination of the heterogeneity of populations, interventions, and outcomes. Finally for each Guiding Question, the body of evidence was assessed for each relevant outcome (benefits and harms), study design, methodological quality, volume of data (number of studies and subjects), consistency, and precision. The body of evidence for each outcome across studies will be rated using the AUA system of A, B, or C.

A = well-constructed RCTs or extremely strong and consistent observational studies

B = RCTs with weaknesses of procedures or applicability or moderately strong and consistent observational studies

C = observational studies yielding inconsistent findings or that have other problems

Results and Strength of Evidence for Each Guiding Question

Upon completion of the abstract review, 609 articles were selected for full text retrieval. This large set was subsequently narrowed by systematically setting aside articles with content related to topics that were not critical to the objective or were difficult to assess. These included the topics of follow-up, cost, and review-based literature. After this removal step, 411 remaining articles were prioritized for extraction based on content. At the time of this writing all extractions have been completed, and the body of evidence for each Guiding Question has been evaluated and summarized. To view of a table of Guiding Questions that have been addressed and associated evidence levels, please see **Appendix B**. Articles in this report are referenced by unique identification numbers (UIDs) corresponding to the full text review procedure (please see Appendix D for the full list of articles by UID).

On Effective and Appropriate Imaging Modalities for Ureteral Stones

A total of six Guiding Questions posed by the panel were related to the overall suitability and effectiveness of imaging modalities for diagnosis and management of ureteral calculus disease in defined index patient populations (GQs 1-6). No relevant studies that met the inclusion criteria were identified that discussed the most appropriate modalities for follow-up imaging of known calculi or following treatment in pregnant patients (GQ6).

The first Guiding Question (GQ1) sought to determine the most appropriate and effective imaging modality for adult patients with symptoms of ureteral calculi. A large number of articles (n=145) provided some relevant information and conclusions related to this question. There was substantial disparity across these articles in terms of study design and modalities evaluated, but in each study the authors typically reported a conclusion or recommendation regarding the most appropriate or effective imaging modality to use for patients upon initial presentation. The distribution of recommendation across the 145 studies was as follows: CT (97), CT + nuclear medicine (4), CT + US (1), CT + X-ray (1), CT + MRI (1), IVP (13), MRI (3), US (13), US + IVP (1), US + X-ray (7), and X-ray (4). As expected, the vast majority of studies concluded that CT was the most appropriate modality either alone or in conjunction with another modality such as nuclear medicine, US, X-ray, or MRI. Studies that recommended usage of IVP were usually published before the year 2000 and did not evaluate CT, indicating a transition in the gold standard for detecting ureteral calculi from IVP to CT. Articles recommending the use of US as the primary modality of investigation often acknowledged its lower sensitivity in detecting calculi relative to CT, but stated that differences in overall cost, availability, and radiation concerns made US preferable.

Four studies that recommended use of CT and renal scintigraphy (CT+NM) <#120, 126, 170, 267> consistently argued that the functional information from scintigraphy augments the CT scan and assists in developing treatment options for the patient. Details of many of these studies are summarized in the Guiding Questions to follow.

Additionally, we examined the recommendations of the recent American College of Radiology: ACR Appropriateness Criteria for Acute Onset Flank Pain — Suspicion of Stone Disease (2011). In this report, an expert panel performed a literature search to assess the most appropriate modalities for imaging of ureteral stones in different patient populations. Upon initial presentation with suspicion of stone disease, the highest rated radiologic procedure (with a rating of 8) was non-contrast CT of the abdomen and pelvis with reduced-dose techniques as the preferred protocol. If unenhanced CT fails to explain patient pain or if an identified abnormality needs to be further assessed, the ACR panel suggests use of CT with contrast in most patients.

For pregnant patients, patients with allergies to iodinated contrast or in cases where non-contrast CT is not available, the ACR panel recommends initial evaluation with ultrasound of kidneys and bladder retroperitoneal with Doppler and KUB. Furthermore, the report notes that non-contrast CT using an ultra-low-dose protocol could also be considered in pregnant patients in the second and third trimester. For patients with recurrent symptoms of stone disease, the ACR panel recommends an initial assessment with either low-dose non-contrast CT or ultrasound of kidneys and bladder retroperitoneal with Doppler and KUB. In this case, both modalities are given an equivalent rating of 7.

In cases of follow-up after treatment and in patients with known calculi, the report indicates that plain X-ray KUB is the most appropriate modality. Use of MRI and IVP for imaging was also described, but these techniques were not recommended as the preferred modality under any conditions.

Strength of Evidence: The quality of this body of evidence is high **(level A)**. Though most of the retrieved studies represented observational studies, the broad consensus is that unenhanced CT is the most effective and appropriate investigation of choice in the initial examination of adult patients with acute flank pain, and that reduced-dose protocols should be utilized when possible. Application of renal scintigraphy may also be prudent in combination with CT.

With respect to pediatric patients with initial presentation of renal colic (GQ2), 15 related studies were found. In terms of overall imaging utilization, Routh et al. <#389> analyzed major trends in imaging and surgical management urolithiasis in younger patients. By searching the Pediatric Health Information System database from 1999 to 2008, they identified 7,921 children diagnosed with urolithiasis (mean age: 11.9 yrs, max: 18 yrs), of whom 6,318 (80%) underwent stone-related diagnostic imaging. During this 10-year period, computerized tomography use was found to have increased (26% to 45%) and plain KUB X-ray plus IVP use decreased (59% to 38%) ($p < 0.0001$). CT use was associated with older patient age, nonwhite race and public insurance. This study found overall that surgery and imaging for pediatric urolithiasis remained stable at pediatric hospitals in the last decade, but computerized tomography use has increased.

Four articles <#145, 147, 344, 353> directly recommended usage of unenhanced CT in the pediatric population. Three studies reported results of CT detection of calculi in patient groups ranging from 17 to 315 patients. Two studies found CT to be significantly more accurate and more informative than other modalities (such as US or IVP), though conventional diagnostic accuracies were not reported. A simulation study found that artificial dose reduction was a useful tool for determining diagnostic thresholds for MDCT detection of renal stones in children. An 80-mA setting for all children and 40 mA for children weighing 50 kg or less did not significantly affect the diagnosis of pediatric renal stones. They therefore recommended usage of a CT in a reduced dose protocol.

Four studies examining the accuracy of CT and US in young patients (group sizes 20-75 patients) all found CT to be significantly more accurate overall than US. Three studies concluded that US should be the first imaging modality in children with suspected urolithiasis, followed by CT if US is inconclusive. The remaining study recommended plain film KUB as a first-line imaging procedure, followed by CT if X-ray was inconclusive.

One study <#386> of CT and US accuracy in 217 patients comprised of adult and pediatric patients chose to err on the side of caution and stated that US should always be the first modality of investigation in spite of its lower sensitivity, and further that US re-examinations should be preferred to irradiating the subject with CT.

Two articles focused on nuclear medicine techniques in this population. One study <#249> assessed diuretic renography (DR) in 18 patients 1 month to 10 years old with unilateral hydronephrosis, but found that obstruction is particularly likely to be misdiagnosed in children younger than 2 years due to exaggerated pelvic volume expansion. The authors state that DR appears to be particularly vulnerable to inaccuracy in diagnosing obstruction in pediatric patients. A conflicting study <#304> evaluated 51 patients aged 3 months to 14 years, who presented with unilateral moderate to severe hydronephrosis with suspicion of pyeloureteral junction obstruction. All patients underwent DR as a gold standard of obstruction and evaluation of ureteric jets by transverse color Doppler US of the bladder. The number of ureteric jets was counted during a 5-min period, and the frequency of jets was calculated for each ureteral meatus in every patient. Relative jet frequency (RJF) was calculated as the jet frequency of the hydronephrotic side divided by the sum of both ureteral jets. Relative jet frequency measured using Doppler US was found to be particularly useful in detection of obstruction: a RJF < 25% resulted in 87% sensitivity and 96% specificity.

Strength of Evidence: The quality of this body of evidence is low **(level C)**. While the evidence indicates that CT is more accurate and effective than US for pediatric patients, radiation concerns often prohibit the authors from exclusively recommending CT. Instead the recommendation is US followed by CT. However, as low dose CT protocols are more thoroughly studied, they may replace this approach. Ultrasound is universally agreed to be safe, but its poor sensitivity for stone detection is problematic for practitioners.

The panel indicated that pregnancy is a critical factor when considering imaging modalities for suspected ureteral calculi (GQ3). Fetal irradiation, contrast allergies, and the likelihood of physiological hydronephrosis are all significant concerns that must be mitigated while still achieving reasonable diagnostic sensitivity and specificity. Twelve studies were identified as relevant to GQ3.

The primary article of interest for the panel here is by White and colleagues <#297>, who retrospectively reviewed the usage of low-dose non-contrast CT in 20 pregnant patients with acute flank pain (mean gestational age 26 weeks). All patients underwent renal US evaluation before low-dose CT. The average radiation exposure was 705.75 mrads (range 210-1372 mrads; SD +/- 338.66 mrads). This is significantly lower than the standard CT radiation dose of 2500 mrads. Of the 20 patients, CT demonstrated urinary stones in 13 patients ranging from 1 to 12mm. The authors cite studies that indicate that the radiation dose applied in this protocol does not measurably increase the risk of cancer to the fetus. This is the only article in the extracted literature that utilized CT on pregnant patients.

Over a two-year period, Irving and Burgess <#173> examined 15 pregnant women with a history of severe loin pain believed to be of renal origin using a limited two-film IVP protocol. The authors found IVP has a much higher detection rate than US particularly in the detection of ureteric calculi, and also provides more functional information. They conclude that IVP is a safe and appropriate investigation in the assessment of loin pain in pregnancy.

Four articles <#49, 50, 106, 237> had relevance to GQ3 that studied the value of MR urography (MRU) in determining the level and degree of ureteric obstruction. The most comprehensive study with respect to pregnancy was Spencer et al. <#237> which evaluated MRU appearances in 24 symptomatic hydronephrosis cases and compared patterns in physiological hydronephrosis and calculous disease. In each of these cases, hydronephrosis was confirmed by US, but was otherwise inconclusive. MRU consisted of an overview fast T2-weighted examination of the abdomen and pelvis, and thick slab, heavily T2-weighted MRU images, followed by focused, high-resolution T2-weighted sequences obtained in an axial and coronal oblique plane. Of the 24 patients, 15 were found to have physiological hydronephrosis, 7 had calculous disease and 2 had preexisting urinary anomalies. Spencer et al. concluded that US should remain the first line investigation for loin pain in pregnancy and most clinical problems can be solved with a combination of US and clinical judgment. However, they note that MRU has potential as a problem-solving tool, allowing the distinction of physiological from pathological obstruction of the ureter as well as confident and direct identification of the size of urinary calculi and the exact site of ureteral obstruction.

An additional well-performed study <#50> examined 17 pregnant women with acute flank pain using RARE (rapid acquisition with relaxation enhancement) MR urography or RMU. This technique was able to detect urinary tract dilatation and the level of obstruction with 100% sensitivity. Additionally, the determination of the type of obstruction, intrinsic versus extrinsic, was always exact. While the RMU technique was able to differentiate a physiological from a pathological ureterohydronephrosis during pregnancy, alone it could not specify the exact nature of the obstruction. The authors concluded that RMU could be considered as the procedure of choice when US fails to establish the differential diagnosis in pregnant patients.

Finally, six studies assessed the utility of ultrasound in this index patient group <#81, 107, 129, 175, 307 333, 369>, however not all studies were concerned with detection of calculi, but rather diagnosing obstruction. Four studies focused on the direct detection of calculi:

In Parulkar et al. <#81> a set of 70 patients was assessed, and the authors reported sensitivity in detecting calculi of 95.2% and specificity of 87% using "clinical scenario" as a gold standard. This was somewhat ambiguous to the reader. They also noted watchful conservative nonsurgical treatment resulted in spontaneous passage of stones in 64.3% of cases.

Butler et al. <#107> performed a retrospective case series of 57 women (mean gestational age 23 weeks) who had symptomatic nephrolithiasis. Imaging techniques included renal ultrasonography, plain abdominal X-ray, and single-shot IVP. Calculi were visualized in 21 of 35 (60%) renal US examinations and 4 of 7 (57%) abdominal X-ray studies when these were performed as the initial test. In contrast, urolithiasis was discovered in 13 of 14 (93%) instances in which intravenous pyelography was performed as the initial diagnostic test. The authors state that if US is inconclusive, then limited IVP is an appropriate next step in diagnosis. Kochakarn et al. <#175> had similar sensitivity results for US and made similar conclusions regarding limited IVP as a next step.

Andreoiu and MacMahon <#333> was a retrospective analysis of 262 patients assessing Doppler US as an initial investigation. They found left-sided colic was more likely to indicate presence of stone (64.9% vs 46.6%, P = .003). Additionally, the accuracy of US findings in predicting presence of stone improved (from 56.2% to 71.9%) when features of obstruction, such as ureteric jet absence and an elevated resistive index (RI), were included in the assessment.

The remaining two studies commented on the ability of Doppler US to detect obstruction in pregnant patients, in one of which the authors concluded that the deltaRI is a sensitive and specific test that can replace intravenous urography in the diagnosis of acute unilateral ureteral obstruction in pregnant women with SN/SP of 95%/100%.

Strength of Evidence: The quality of this body of evidence is low **(level C)**. While there is agreement that ultrasound and MRU are both noninvasive and safe procedures, their variable reported accuracies for detection of calculi are a major concern. The low-dose CT protocol is highly accurate, but there is only one study citing it. The ACR appropriateness criteria report also confirms that ultrasound and ultra-low-dose unenhanced CT would be appropriate for imaging of pregnant patients. More studies are needed to improve this body of evidence.

Follow-up imaging was also chosen as an important issue by the panel (GQ4, GQ5, GQ6). The literature search found 28 articles with respect to follow-up imaging of adult patients with known stones or after treatment (GQ4). Of these, eight discussed follow-up imaging of known stones without intervention, while 20 described imaging after treatment such as ESWL or ureteroscopy. Additionally, after the initial literature search, further studies were retrieved to assist the panel with this topic.

In a landmark paper by Miller and Kane (1999), 75 patients with urolithiasis were followed for up to 105 days in order to characterize natural stone progression and distinguish factors predictive of stone passage. While initial diagnosis was performed using CT or IVP, follow-up imaging of these known calculi consisted of plain radiography in most cases, or limited IVP if the stone was not easily visualized on X-ray. Of the 75 patients (mean age 37 years), 13 required intervention while 62 achieved spontaneous stone passage. Of stones 2mm or less it took 31 days for 95% of stones to pass spontaneously. Of stones with sizes 2-4mm and 4-6mm, it took 40 days and 39 days for 95% of the stones to pass, respectively. Multivariate analysis revealed that size, location and side were statistically related to stone passage interval ($p = 0.012$). Stones that were small, toward distal and located on the right side were more likely to pass spontaneously and required fewer interventions. The authors conclude that 95% of stones sizes 2-4mm will pass spontaneously but may require 40 days to do so, and that about 50% of calculi >=5mm will require intervention.

Wimpissinger et al. (2007) prospectively studied patients over a 12-year period presenting with asymptomatic calculi located in the ureter. The aim of the study was to evaluate the mode of diagnosis of silent ureteral calculi. A total of 40 patients were identified with asymptomatic calculi, representing 1.1% of all recorded patients with ureteral stones.

Patients had a mean stone size of 10mm and in the following locations: proximal (n=19), mid (n=3), and distal (n=18). Twenty-six out of the 40 patients (65%) were diagnosed with hydronephrosis. The authors reported the mode of diagnosis of these calculi as follows: randomly diagnosed hydronephrosis in 10 patients (25%), microscopic hematuria in 8 patients (20%), randomly diagnosed stone on other than urological X-ray examination in 13 (32.5%), and stone diagnosed during follow-up after previous nephrolithiasis in 9 patients (22.5%). Two groups of patients could be identified among these subjects, i) patients with previous nephrolithiasis who had an asymptomatic ureteral stone detected on routine follow-up, and ii) patients who had a stone or related signs diagnosed during non-urological radiological examinations. The authors emphasize that the potential development of asymptomatic stones in the ureters of patients who previously have been diagnosed with nephrolithiasis highlights the importance of data on nephrolithiasis recurrence and the need for routine follow-up.

Irving et al. (2000) sought to determine the efficacy of conservative management of ureteral stones > 4mm using renography to evaluate changes in renal function. In this prospective study, 54 patients with symptomatic ureteral stone were recruited. Stones were located in the upper third (n=18), middle third (n=12), and lower third (n=24) of the ureter. Of the 54 patients, 28% had 'silent' loss of renal function at presentation. No calculi >7 mm in diameter successfully passed without intervention. The authors concluded that stones of 5-7 mm in diameter are safe to treat conservatively if regular renography is utilized to assess differential renal function.

Weizer and colleagues (2002) retrospectively studied the incidence of postoperative silent obstruction among 241 patients undergoing ureteroscopic procedures and assessed the need for routine functional radiographic studies after ureteroscopy. Of the 241 patients, 30 resulted in postoperative obstruction due to residual stone in 25 (83.3%), stricture in 3 (10%), edema of the ureteral orifice in one case and a retained encrusted stent in one case. Obstruction correlated with postoperative pain in 23 of the 30 patients. However, silent obstruction developed in 7 patients (23.3%) or 2.9% of the total cohort. All 7 patients underwent secondary ureteroscopy to alleviate obstruction. One patient received chronic hemodialysis for renal failure, one was lost to follow-up, and successful treatment was documented in five. The authors conclude that restricting postoperative imaging to only symptomatic patients is not worth the risk of jeopardizing the renal function of 3% of patients who have asymptomatic obstruction. In terms of protocol the authors suggest that post-operative imaging should be performed by IVP, CT, or ultrasound within 3 months after routine ureteroscopic stone intervention.

Kelleher et al. (1991) performed a prospective study aiming to evaluate if patients at risk of permanent renal damage could be identified using renography. The patient population included 76 patients with acute calculus obstruction demonstrated on IVP. Patients underwent ^{99m}Tc-DTPA renography within 24 hours of admission, and also (if needed) at 72 and 96 hours. Overall stones >5mm in diameter were highly likely to cause obstruction, a drop in renal function, and require intervention. Using this modality, the authors also found a subpopulation of patients that had become pain-free after 3 or 4 days, but were still obstructed. Therefore, they emphasize the importance of following a patient after intervention to confirm stone free status, and further recommend renography when conservatively managing stones >5mm in diameter.

The remaining seven papers that focused on imaging without intervention had disparate recommendations regarding follow-up imaging of known stones. Two studies <#315, 317> utilized X-ray during follow-up, typically to confirm a stone's presence and assist in treatment decisions. One study <#015> used US serially to assess patients with ureteral obstruction every 48 hours for up to one week and at 3-month intervals after discharge. A conflicting study <#388> which was more recent (2010) concluded that the poor of sensitivity of US and its typical overestimation of stone size precluded its use for informing treatment decisions. One nuclear medicine study using 99mTc-DTPA renography <#9> evaluated 76 patients with previously confirmed acute calculus obstruction to see if kidneys at risk of irreversible renal damage could be identified. They discovered a statistically significant relationship between the presence of obstruction on renography and the subsequent requirement for intervention, but not with the degree of obstruction (partial or severe). The authors concluded that stones over 5 mm in size are highly likely to cause obstruction, a drop in relative renal function and may require intervention. Therefore, renography can be very informative for evaluating the need for intervention in patients with confirmed urolithiasis. Finally two articles <#038, 316> suggested the use of repeated CT scans as follow-up in patients with calculi. The first paper <#038> by Smith et al. (1995) was a pioneering paper on the use of CT scans for detection of calculi, while the second paper utilized CT to confirm stone expulsion in patients who complained of persistent symptoms of renal colic.

The set of 20 studies that employed follow-up imaging after treatment of calculi were associated with SWL (17), ureteroscopy (2), or holmium laser lithotripsy (2) as the primary intervention. These studies did not attempt to evaluate the effectiveness of different modalities, but rather report their follow-up imaging protocol. One exception was by Macejko et al. <#346> which compared stone free rates (SFRs) for multiple imaging modalities in 92 patients undergoing ureteroscopy for either renal or ureteral stones. They authors found that due to its high accuracy, CT-based SFRs were significantly lower than SFRs calculated using X-ray or IVP imaging when equivalent fragment size thresholds were required (<=2mm). This indicates that fragment size estimation by different modalities may be biased, thereby affecting overall treatment success rates. Among the remaining 19 studies, 16 exclusively used US and/or X-ray during treatment follow-up at time intervals ranging from 1 week to 12 weeks. No studies employed nuclear medicine or MRI in treatment follow-up.

Strength of Evidence: The quality of this body of evidence is low **(level C)**. Based on the limited information in the retrieved articles, there is high variability in choice of imaging protocols for follow-up either to observe progression of stone or to evaluate treatment success. No comparative analysis of the effectiveness of imaging modalities for follow-up was identified with the exception of Macejko et al. <#346>.

Only four studies <#071, 350, 372, 394> were identified as relevant to follow-up imaging of pediatric patients (GQ5). One study <#372> focused on younger patients, but not all patients met the pediatric age criterion (≤ 14 years). However the mean age of the patient group was 5.3 years, so we include it in this summary. At least 50 patients were used in each study, and in three studies the patient group was treated with SWL. These treatment-based studies documented their follow-up imaging protocols. In <#071>, US and plain film KUB were utilized immediately as follow-up. The treatment was repeated two weeks later if there was incomplete fragmentation seen on a repeat KUB. Children with adequate stone fragmentation were followed up by KUB and US at monthly intervals until the stone was completely cleared. Stone free success rates were computed based on 3-month follow-up results. Ultrasound and plain films were also used in the other two SWL treatment studies for immediate follow-up, and one study performed CT or IVP three months after the patient's last SWL session. The fourth study <#350> assessed diagnostic accuracy of ultrasound and non-contrast CT in pediatric patients, ultimately concluding that ultrasound is the "ideal" routine follow-up imaging technique.

Strength of Evidence: The quality of this body of evidence is low **(level C)**. There is no follow-up diagnostic accuracy information in these four studies, nor is there any evaluation of whether US or plain film X-ray are both essential for post-treatment imaging in pediatric patients.

Diagnostic Accuracy of Modalities

A total of six Guiding Questions posed by the panel were related to the diagnostic accuracy (sensitivity/specificity) of imaging modalities for either calculi or some level of obstruction (GQs 7-12). Guiding Question 7 aimed to determine the accuracy of non-contrast CT in identifying ureteral calculi, while the remaining questions sought to determine the accuracy of other imaging modalities relative to CT (GQs 8-11) or for detecting obstruction alone (GQ12). Initially we expected in the literature review to find a large number of articles that employed CT as the "gold standard" for detection of calculi, however in most studies of diagnostic accuracy, clinical, surgical, and alternative imaging follow-up was used as the reference standard for presence or absence of calculi. CT was utilized as the gold standard in eight studies. In these cases, we performed the QUADAS evaluation as described in the methodology protocol (see Supplementary Table 2, Appendix E), but for most diagnostic studies this was not applicable. Therefore, in this analysis we shall assess all diagnostic accuracy trials regardless of the selected reference standard.

There were 89 studies relevant to at least one of GQs 7-11. Examining the extracted data of these selected articles, we identified 58 studies with acceptable reference standards (including clinical, surgical, and/or imaging confirmation) and sensitivity (SN) / specificity (SP) results. Table 1 displays the reported SN/SP results from these studies as well as information about the total number of stones analyzed or the size of the patient population with confirmed urolithiasis.

With regard to the diagnostic accuracy of CT in detecting ureteral calculi (GQ7), we observe in Table 1 that 37 studies reported SN/SP results for standard-dose CT, the first of which was published in 1996 (Smith et al. <#054>). Sensitivities and specificities of CT imaging ranged from to 90% to 100% and from 84% to 100%, respectively. Out of 36 studies that reported SN/SP for CT as a single modality (that is not in combination with other techniques), 24 studies reported SNs > 98%, while 12 reported perfect SNs of 100%.

Additionally, six diagnostic trials <#119, 172, 203, 213, 266, 401> assessed the accuracy of low-dose CT protocols designed to mitigate radiation exposure to the patient while maintaining efficacy. In the six trials, low-dose CT performed remarkably well (even with significantly decreased radiation levels near that of IVP), resulting in reported sensitivities ranging from 92.1% to 97%, and specificities ranging from 95% to 100%. Only in obese patients with higher body mass index (e.g. > 31 kg/m^2) is conventional unenhanced helical CT with higher radiation exposure recommended to achieve adequate image quality.

Strength of Evidence: The quality of this body of evidence is high (**level A**). Non-contrast CT consistently demonstrates exceptional diagnostic accuracy in detection of ureteral calculi in the vast majority of relevant studies and has been used as the gold standard of detection in others. With the caveat of obese patients, alternative low-dose CT protocols also maintain sensitivity and specificity levels above 90%.

Notwithstanding CT, Table 1 lists less consistent SN/SP results for other imaging modalities. For conventional radiography, sensitivities ranged from 18.6% to 95%, and specificities from 61% to 95.1%. For ultrasound, reported sensitivities ranged from a dismal 3% to 98%, and specificities from 55% to 100%. Similarly for IVP, the documented sensitivity and specificity ranges were 52-100% and 89.7%-100%, respectively. Three articles reported diagnostic results for MRI with SNs of 69.2%, 82%, and 97%, and two articles noted high specificity (>96%).

Combinations of two imaging technologies were also assessed in some studies. Seven studies utilized a combination of conventional radiography and ultrasound (X-ray+US) in diagnostic trials, however there was again significant variability in reported sensitivity and specificity results. Sensitivities ranged from 58 to 100%, while specificities ranged from 37.2 to 100%.

A total of 36 studies compared the accuracy of a modality directly to CT (either as the exclusive gold standard or a tested technology). The median reported sensitivity and specificity values are given in Table 2. Ultimately, no modality or combination of modalities was found to consistently perform as well as non-contrast CT.

Strength of Evidence: The quality of this body of evidence is low (**level C**). No other modalities (or combination of modalities) demonstrated consistently high (or low) SN/SP results in these diagnostic accuracy studies.

Table 1. Sensitivity and specificity results for 59 diagnostic accuracy trials. Modalities are listed by code. Multiple modalities utilized in combination are denoted by a '+' sign. The code "**CT***" corresponds to a low-dose CT protocol designed to limit radiation exposure. The reported order of accuracies for each imaging modality (or combination of modalities) is sensitivity, specificity, positive predictive value, and lastly negative predictive value. Missing values are not shown i.e. for an entry such as "IVP: 95.6%" indicates that the SN reported was 95.6% for the study, but SP, PPV, and NPV were not described.

Article UID	Lead Author	Year	Total calculi or patients/renal units with calculi	Reference standard	Overall sensitivity/specificity/PPV/NPV
010	Mutgi A	1991	72	IVP and/or stone retrieval	X-ray: 58%/69%/91%/23%, IVP: 94%/100%/100%/76%
012	Al Rasheed SA	1992	45	Clinical diagnosis	X-ray: 80%, US: 91.1%, IVP: 95.6%, X-ray+US: 100%
015	Haddad MC	1992	69	IVP and clinical follow-up	IVP: 88%/100%, US: 10%/100%, X-ray: 49%/90%
022	Dalla PL	1993	44	IVP and clinical follow-up	X-ray: 77%/87%/81%/84%, US: 25%/100%/100%/65%, US+X-ray: 95%/67%/68%/95%, IVP: 100%/100%/100%/100%,
042	Boyd R	1996	28/51 patients	IVP	X-ray 68%/96%/95%/71%
044	Gorelik U	1996	98/158 patients	IVP	X-ray: 95%/65%/82%/88%, US: 93%/83%/93%/83%, X-ray+US: 89%/100%/100%/81%

054	Smith RC	1996	100/210 patients	Alternate imaging or surgical or clinical recovery	CT: 97%/96%/97%
061	Fielding JR	1997	55/100 patients	Spontaneous passage, retrieval, or follow-up imaging	CT: 98%/100%/100%/97%
067	Levine JA	1997	79/178 patients	CT	X-ray: 59%
074	Dalrymple NC	1998	184	Additional imaging and clinical followup	CT: 96%/99%/98%/97%
079	Miller OF	1998	75	Positive CT or IVP	CT: 96%/100%/100%/91%, IVP: 87%/94%/97%/74%
085	Vieweg J	1998	49/105 patients	Clinical follow-up	CT: 98%/98%
086	Yilmaz S	1998	64/97 patients	Stone passage or recovery by urological intervention	US: 19%/97%/92%/38%, IVP: 52%/94%/94%/50%, CT: 94%/97%/98%/89%
091	Boulay I	1999	51	Clinical records	CT: 100%/96%
094	Dorio PJ	1999	98	Clinical records	CT: 98.5%/95.6%/95.6%
098	Niall O	1999	28	Clinical and radiological followup	X-ray: 54%/67%, IVP: 64%/92%, CT: 100%/92%

104	Sourtzis S	1999	36	Clinical confirmation or radiological findings	IVP: 66.7%/100%, CT: 100%/100%
111	Erdogru T	2000	173	Surgical recovery, clinical follow-up, or stone passage	CT: 100%/98%
119	Liu W	2000	37	Spontaneous stone passage, surgical stone retrieval, and other imaging.	IVP: 70%/96%, CT*: 97%/96%
121	Nachmann MM	2000	92/281 patients	Spontaneous stone passage, surgical stone retrieval, and other imaging.	CT: 97%/92%/88%/98%
125	Rosser CJ	2000	56	Follow-up interview or records	CT: 93.6%/84.7%/88%/91.6%
127	Sheafor DH	2000	23	Follow-up surgery, alternative imaging, or clinical follow-up	US: 61%/100%, CT: 96%/100%

136	Hamm M	2001	91	Urologic intervention or alternative imaging	X-ray: 47%/76%/84%/35%, US: 11%/97%/91%/29%, CT: 99%/97%/99%/97%
138	Homer JA	2001	159/228 patients	Clinical outcome	IVP: 99%/100%, CT: 100%/100%
140	Jeng C	2001	121	IVP	X-ray: 63%/80%, CT: 98%/94%
144	Longo J	2001	105	Clinical outcome	IVP: 83%/95%/97%/67%, CT: 98%/95%/98%/95%
148	Patlas M	2001	43/62 patients	Clinical follow-up	US: 93%/95%/98%/86%, CT: 91%/95%/98%/82%
149	Shokeir AA	2001	52/109 patients	IVP and clinical follow-up	CT: 96%/96%
170	German I	2002	46	Alternative Imaging	X-ray: 52.2%, CT: 100%
172	Hamm M	2002	80/109 patients	Urologic intervention or alternative imaging	US: 3%/97%/67%/26%, CT*: 96%/97%/99%/90%
179	Shokeir AA	2002	42	Urologic intervention or alternative imaging	X-ray+US: 58%/93%, CT: 94%/96.5%
181	Sudah M	2002	32/49 patients	Clinical confirmation	CT: 90.6%/97%, MRI: 97%/100%
183	Ahmad NA	2003	148	Clinical records	CT: 99%/98%/99%/98%

187	Eray O	2003	54/65 patients	CT or spontaneous passage	X-ray: 69%/82%, CT: 91%/91%
197	Mendelson RM	2003	107/200 patients	Clinical outcome	IVP: 79.2%, CT: 98.4%
203	Tack D	2003	38/106 patients	Urologic intervention or alternative imaging	CT*: 92.1%/97.1%
205	Ueda K	2003	50/100 patients	CT or intervention and follow-up	X-ray: 62%/70.8%
213	Blandino A	2004	44	CT observation of stone, alternative imaging, surgical intervention, and clinical follow-up	MRI+CT*: 98%, CT: 100%
230	Oner S	2004	57	Clinical confirmation	US: 68.9%/83.3%, CT: 100%/100%
234	Ripolles T	2004	55/66 patients	Stone passage, urologic procedures, or US and CT	X-ray+US: 78.6%/100%/100%/45.5%, CT: 92.9%/100%/100%/71.4%
235	Shokeir AA	2004	146/259 renal units	Urologic intervention or alternative imaging	MRI: 69.2%/96.5%, X-ray+US: 78.8%/37.2%, CT: 100%/98.2%

239	Wang LJ	2004	66/82 patients	Urologic intervention or recovery	IVP: 74.2%/100%/100%/48.5%, CT: 100%/93.8%/98.5%/100%
253	Palmer JS	2005	75	Radiographic evidence	US: 70%, CT: 99%
256	Pepe P	2005	90/100 patients	Contrast enhanced CT	US: 94%/55%, CT: 100%/96%, CT+US: 100%/100%
266	Kluner C	2006	102/142 patients	Stone removal/discharge or clinical and imaging follow-up	US: 67%/90%, CT*: 97%/95%,
267	Kravchick S	2006	49	Clinical follow-up, spontaneous passage, surgical intervention	X-ray: 72%/61%/82%/46%, X-ray + NM (1): 75%/93%/97%/54%, X-ray + NM (2): 82%/86%/95%/56%, CT + NM: 96%/85%/96%/85%
285	Mitterberger M	2007	75/98 patients	Clinical confirmation	X-ray+US: 96%/91%/97%/88%, CT: 100%/100%/100%/100%
300	Chan VO	2008	176	CT	X-ray: 18.6%/95.1%/84.6%/44.8%
321	Park SJ	2008	313	CT or IVP	US: 98.3%/100%
325	Sen KK	2008	17	CT	US: 82%, IVP: 88%, MRI: 82%
331	Wang JH	2008	66/82 patients	Endoscopic evaluation, operative findings, and follow-up course	IVP: 59%/100%/100%/37.2%, CT: 98.4%/100%/100%/94.1%

350	Passerotti C	2009	34/50 patients	CT	US: 76%/100%/100%/67%
366	Ben Nakhi A	2010	14/36 patients	CT	IVP: 57%/100%
374	Hu H	2010	41/65 patients	Surgery, pathology or clinical follow-up	IVP: 59.0%/89.7%, IVP+CT: 97.6%/91.3%,
377	Jung S Ii	2010	163	CT	X-ray: 29.4%
386	Mos C	2010	217	X-ray, IVP, CT, or stone passage	X-ray: 48.39%, IVP: 68.37%, US: 73.27%, CT: 91.11%
388	Ray AA	2010	71	Meta-analysis used CT and follow-up as reference	US: 44.6%/90.6%/86.5%/54.8%
401	Fowler JC	2011	31	Interventional findings and clinical outcome	IVP: 84%/95%/96%/81%, CT*: 97%/100%/100%/96%

Table 2. Median reported SN/SP for modalities of interest in studies relative to non-contrast CT.

Modality	Median SN	Median SP
Conventional radiography	57%	76%
Ultrasound	67%	97%
Intravenous pyelography	70%	95%
MRI	82%	98.3%
CT (not as gold standard)	98%	97%

The final Guiding Question in this section relates to nuclear medicine studies for identification of ureteral obstruction or renal damage (GQ12). Six articles were found to be relevant to this Guiding Question.

Two early case series <#002,009> evaluated the use of technetium-99m DTPA renal scintigraphy in patients with suspected obstruction. One study of 40 patients with acute renal colic assessed the accuracy of nuclear medicine to diagnose the obstruction, and found that the level of obstruction could be ascertained from scintigraphy scan alone in 75% of cases. Utilizing plain film results with the scan increased this accuracy to 91%. In the remaining cases, the level of obstruction was indeterminate. A second study of 76 patients with known calculi (confirmed by IVP) used renography to see if kidneys at risk of irreversible renal damage could be identified. Renography was used as follow-up after IVP identified that patients were obstructed. Fifty-one percent of patients were still obstructed one day after admission, 69% of which had severe obstruction, 31% had partial obstruction. There was a statistically significant relationship between the presence of obstruction on renography and the subsequent requirement for intervention ($p < 0.01$), but not with the degree of obstruction (partial or severe). In both of these studies, the diagnostic accuracy of nuclear medicine for obstruction is questionable because the modality was employed as part of the reference standard.

Four articles discussed usage of renal scintigraphy in conjunction with non-contrast CT <#120, 126, 170, 267>. Although these studies also did not evaluate the diagnostic accuracy of renography in detecting obstruction, all four studies concluded that it is clinically useful to employ renography in evaluation of renal colic with CT. The consensus among these articles was that scintigraphic findings provide important information not easily determined by CT alone. In particular, when secondary signs of obstruction are present on CT, renal scintigraphy can distinguish patients with different degrees of obstruction and aid in selecting patients who need early intervention.

Strength of Evidence: The quality of this body of evidence is moderate (**level B**). Due to the consistent use of renal scintigraphy as the gold standard (or part of the reference standard) across these six observational studies, it is likely the most effective imaging modality for assessing functional obstruction in patients with renal colic. Additionally, the ability of nuclear medicine studies to detect not only the presence, but also level of obstruction makes it a useful tool in conjunction with unenhanced CT when a calculus is detected.

Additional Important Factors

Eight Guiding Questions assessed during the literature review were related to the implications of ancillary conditions and secondary information obtained via imaging (GQs 13-20). There were no articles that reported substantial conclusions regarding extravasation in patients (GQ15).

With respect to studies of duration and location of pain (GQ13), the literature review identified three relevant articles. Heneghan et al. <#63> performed a retrospective study to determine the value of the ureteric soft-tissue 'rim' secondary sign for differentiation of ureteral calculi from phleboliths on CT. A total of 136 patient records with ureteral calculi were reviewed to assess presence of rim sign and any potential correlation with duration of pain. Overall the authors concluded that there was no significant difference in duration of pain between patients positive for calculi whose scans showed rim sign and those that did not ($p = 0.44$).

In a study of 227 patients, Varanelli et al. <#154> examined the relationship between duration of pain and secondary signs of obstruction on unenhanced helical CT including presence or absence of perinephric stranding, ureteral dilatation, perinephric fluid, collecting system dilatation, periureteral stranding, and nephromegaly. All CT secondary signs of ureteral obstruction except nephromegaly showed a significant increase in frequency as duration of flank pain increased. The frequency of moderate or severe perinephric stranding increased from 5% at 1--2 hr to 51% at 7--8 hr ($p < 0.001$); ureteral dilatation increased from 84% at 1--2 hr to 97% at more than 8 hr ($p < 0.03$); moderate or severe perinephric fluid increased from 0% at 1--2 hr to 22% at 3--4 hr ($p < 0.03$); collecting system dilatation increased from 68% at 1--2 hr to 89% at 7-8 hr ($p < 0.03$); periureteral stranding increased from 35% at 1--2 hr to 76% at 7--8 hr ($p < 0.004$). This article is also summarized below in relation to secondary signs associated with CT (GQ16).

Andreoiu and MacMahon <#333> was a retrospective analysis of 262 pregnant patients assessing Doppler US as an initial investigation. A majority of patients presented with right-sided colic. The authors found left-sided colic was more likely to indicate presence of stone (64.9% vs 46.6% in right-sided colic, $P = .003$). A larger proportion of right-sided hydronephrosis and colic was caused by uterine compression.

Strength of Evidence: The quality of this body of evidence is low (**level C**). There are no consistent conclusions among these three studies.

We identified 56 articles that were relevant to the diagnostic significance of hydronephrosis in patients with or without urolithiasis (GQ14). Of these 56, we were able to extract the incidence rates of hydronephrosis in patients with calculi in a total of 48 studies. The reported proportions of patients diagnosed with calculi that also had some level of hydronephrosis across these 48 studies ranged from 36% to 100% (mean 83%). Similarly, we extracted non-calculi hydronephrosis incidence rates in 13 studies. In these cases, reported proportions of patient groups without urolithiasis who demonstrated hydronephrosis ranged from 8% to 100% (mean 74.5%). Of these studies, five focused on the pregnant patient groups. Hydronephrosis identified in pregnant patients is often not associated with calculus obstruction. In four of these five studies of pregnant patients, 100% of symptomatic women without calculi had hydronephrosis.

Additionally, eight studies analyzed the association of hydronephrosis with the need for/success of intervention for calculi <#075, 101, 184, 292, 341, 354, 361, 395>.

Fielding et al. <#075> retrospectively reviewed the medical records of 100 patients with ureteral stones who had undergone unenhanced helical CT and excretory urograms. Twenty-nine of the 100 patients required some form of intervention. Overall the authors found that the presence of hydronephrosis was **not** strongly associated with the need for intervention because dilatation of the collecting system was present in most patients and did not correlate with obstruction severity.

Four case-series utilizing SWL for intervention <#101, 184, 354, 361> concluded that the presence of hydronephrosis (or higher degrees of hydronephrosis) was associated with increased treatment failure rates or an increased need for SWL re-treatment. In contrast, Seitz et al. <#292> found in a study of 543 patients undergoing Ho:YAH laser lithotripsy that hydronephrosis did not influence stone free rates, complication rates, or postoperative complication rates.

Hong and Park <#341> performed a retrospective review of 341 patients who underwent ureteroscopic lithotripsy using Swiss Lithoclast. A total of 189, 104, and 48 cases were documented with mild, moderate or severe hydronephrosis respectively. The authors concluded that the success rate decreased significantly as the size of the stone increased ($p < 0.001$), and as the degree of hydronephrosis increased ($p = 0.03$).

Similarly Turunc et al. <#395> reported in their retrospective review of 61 patients, that final stone clearance rate after ureteroscopic stone treatment was higher in those with no and mild ureterohydronephrosis than in the patients with moderate and severe ureterohydronephrosis. However, the difference was not statistically significant (P = 0.118).

Strength of Evidence: The quality of this body of evidence is moderate (**level B**). In patients with ureteral calculi, the majority of patients tend to have some degree of hydronephrosis. However, as noted in several studies, the presence of hydronephrosis is not necessarily indicative of a stone causing obstruction. In all five studies of pregnant patients, the presence of hydronephrosis consistently demonstrated no value in predicting the presence of ureteral calculi. Multiple articles consistently reported that the presence or increased degree of hydronephrosis was associated with SWL failure or an increased need for retreatment.

A total of 25 articles that met the inclusion criteria were found to be directly relevant to secondary signs on CT associated with outcomes in the form of treatment success/failure or spontaneous passage (GQ 16). Secondary signs on CT included calculus size, shape, density, attenuation coefficient, predicted chemical composition, location, as well as other factors such as perinephric fat stranding, perinephric edema, and enlargement.

In Erdogru et al. <#111>, urolithiasis was confirmed in 173 patients by unenhanced CT. Stone localizations were kidney in 77 patients and ureter in 96 patients. 79 patients achieved successful stone passage. Focusing on patients with ureteral stones only, spontaneous passage occurred in 38 cases (40%). In 33 cases of ureteral stones, there were no signs of obstruction on CT; the remaining 63 cases demonstrated signs such as hydroureter, hydronephrosis, perinephric fluid or fat stranding. Overall the authors found that larger stones (>7mm) were significantly less likely to spontaneously pass, but this information was based on combined data from patients with either renal or ureteral stones.

Chowdhury et al. <#277> respectively reviewed 500 consecutive cases of acute renal colic evaluated using CT. Of those, 221 (44%) of patients were diagnosed with urolithiasis, and intervention was required in 28%. There was a statistically significant difference ($p < 0.001$) in stone size between patients requiring intervention (mean 6.6mm) and those managed expectantly (mean 3.7mm). Also there were significant differences among intervention rates on the basis of stone location: renal: 19% (intervention rate), pelvi-ureteric junction: 63%, proximal ureter: 52%, middle ureter: 35%, distal ureter: 30%, vesico-ureteric junction: 11%, bladder: 0%.

Fielding et al. <#075> performed a retrospective review of 100 patients with ureteral stones (1-16mm in diameter), and who underwent unenhanced helical CT. CT scans were then reviewed by two radiologists for six findings: in-plane stone diameter, z-axis stone diameter, location of stone, periureteral stranding, hydronephrosis, and perinephric fluid. Seventy-one patients passed stones spontaneously, and 29 patients required intervention including basket retrieval, ESWL, and laser lithotripsy. Evaluating these factors, the authors found that stones larger than 5mm, located within the proximal two thirds of the ureter, and seen on two or more consecutive CT images are more likely to require endoscopic removal, lithotripsy, or both. Furthermore, perinephretic fluid and periureteral stranding may be caused by edema or lymphatic obstruction and therefore are not strongly correlated with the need for intervention. Boulay et al. <#091> performed a retrospective review of 99 patients for the presence, size, and location of ureteral calculi and the presence and severity of secondary signs of obstruction. Ultimately they found that stone size alone was found to correlate with patient treatment ($p < 0.01$). Stone location and the presence and severity of secondary signs of obstruction e.g. perinephretic fat stranding and edema did not affect patient treatment.

An article by Takahashi et al. <#084> review CT-based studies of 69 patients with a single ureteral stone not located at the UPJ. Secondary findings on CT including tissue rim sign, hydronephrosis, and perinephric fat stranding were graded on a scale of 0-3. After removing patients lost to follow-up, perinephric fat stranding ($P = .044$) and perinephric fluid collections ($p = .021$) were graded significantly higher in patients with spontaneous stone passage. Mean stone diameter was significantly larger ($p < .001$) in patients in whom conservative treatment failed (mean 7.8 mm) than in patients with spontaneous stone passage (mean 2.9 mm). The authors conclude that stone size, degree of perinephric fat stranding and presence of perinephric fluid collections are useful ancillary signs when predicting the likelihood of stone passage.

In a computer modeling study by Parekattil et al. <#232>, 301 patient records that included CT scans for calculi were analyzed to predict the outcome and the duration until passage of ureteral/renal stones. Seven characteristics were identified as significant predictors of stone passage: stone location, largest stone dimension (length), stone width, degree of hydronephrosis, intractable pain, fever greater than 101F and perinephric stranding.

With respect to prediction of stone presence/absence alone <#186> and <#375> found the most reliable signs indicating ureteral obstruction on CT were hydroureter/hydronephrosis, periureteral oedema and unilateral renal enlargement as well as high degree of tissue rim sign and perinephric fat stranding. In addition for <#186>, stones larger than 6 mm located within the proximal two thirds of the ureter, and seen associated with five or more the secondary signs of obstruction, were more likely to require endoscopic removal and/or lithotripsy.

In 227 patients with urolithiasis, Varanelli et al. <#154> examined the relationship between duration of pain and secondary signs of obstruction on unenhanced helical CT including presence or absence of perinephric stranding, ureteral dilatation, perinephric fluid, collecting system dilatation, periureteral stranding, and nephromegaly. All CT secondary signs of ureteral obstruction except nephromegaly showed a significant increase in frequency as duration of flank pain increased. The frequency of moderate or severe perinephric stranding increased from 5% at 1--2 hr to 51% at 7--8 hr ($p < 0.001$); ureteral dilatation increased from 84% at 1--2 hr to 97% at more than 8 hr ($p < 0.03$); moderate or severe perinephric fluid increased from 0% at 1--2 hr to 22% at 3--4 hr ($p < 0.03$); collecting system dilatation increased from 68% at 1--2 hr to 89% at 7-8 hr ($p < 0.03$); periureteral stranding increased from 35% at 1--2 hr to 76% at 7--8 hr ($p < 0.004$).

In a 2002 study by German and colleagues <#170>, CT was utilized to detect ureteral stones in 46 patients as well as dynamic renal scintigraphy (DRS) with Tc-99m DTPA or MAG-3 to distinguish patients with different degrees of obstruction. The authors concluded that when CT demonstrated secondary signs such as hydronephrosis and/or peri-renal and peri-ureteral stranding, then DRS would be informative for patients that may require early intervention.

Strength of Evidence: The quality of this body of evidence is moderate (**level B**). Secondary signs such as stone volume, stone length, and stone size are factors consistently associated with outcomes either in the form of spontaneous passage or successful intervention. Additionally, calculi located in the upper ureter or renal pelvis as well as the presence of hydronephrosis are usually associated with poorer outcomes. There appears to be some disagreement about the value of information from additional secondary signs such as perinephretic fluid and periureteral stranding.

In a statistical modeling study of 1,997 subjects with calculi <#359>, CT was utilized in 10% of patients to measure certain features like stone volume and stone density relative to bone density. In the model, the factors that affected statistically significant 3-month SFRs after SWL were patient sex, age, BMI; the size, volume, and density of the stones; and the presence of multiple lithiasis. In the analysis there were 799 ureteral stones and 1198 renal stones. Specifically for ureteral stones, >0.5cm^3 and stones with density > bone density on CT were statistically associated with a reduction in SFRs after SWL treatment ($p < 0.001$ in both cases). Moreover a multiple logistic regression model for ureteral stones was developed to predict the likelihood of SWL success. Significant factors in the model included stone size, stone volume, and stone density ($p < 0.001$ in all cases). An increase in stone size (or volume) or stone density greater than measured bone density was associated with a lower likelihood of stone free outcome after SWL in this model. A second statistical study <#348> of 94 patients with upper ureteral stones treated with SWL used logistic regression modeling to identify factors associated with successful outcomes. Measures of mean stone density, stone volume, and skin-to-stone distance as measured by CT were found to be successful predictors of SWL for upper ureteral stones. Specifically a scoring rule was constructed based on the 3 factors of stone volume less than 0.2 cc, mean stone density less than 593 HU or skin-to-stone distance less than 9.2 cm. The stone-free rate for patients having 0, 1, 2 and all 3 factors was 17.9%, 48.4%, 73.3% and 100%, respectively.

Wiesenthal et al. <#410> analyzed 422 patient records with CT scans for renal or ureteral stones to create a nomogram capable of reliably predicting shock wave lithotripsy outcomes. Analysis was restricted to patients with CT demonstrating a solitary, radiopaque renal or ureteral calculus between 5 and 20 mm in maximal diameter. For the 204 ureteral stones the success rate was 60.3%. On multivariate analysis of ureteral calculi, predictive factors included body mass index and stone area (> $45mm^2$), but not mean stone density or stone location.

Six additional studies of limited value focused on stone density and other measurements to predict the effectiveness of extracorporeal shockwave lithotripsy. In each study, all patients underwent a CT scan prior to SWL treatment, and attenuation values of visualized calculi were computed (measured in Hounsfield units, HU). However as described below these studies typically did not stratified reported results between renal and ureteral calculi.

Pathak et al. <#352> also had similar results in their study of 89 patients with renal or upper ureteric calculi. After ESWL, the successful and failure groups had mean stone densities of 505 +/- 153 and 803 +/- 93 HU, respectively ($p < 0.001$). This difference was found to be significant for ureteral and renal stones independently. Again calculi in this study were at least 5mm in diameter, and none were located in the middle or distal ureter.

In article <#335>, researchers evaluated preoperative non-contrast CT in 94 patients who had ESWL for solitary upper urinary tract calculi of 4–20 mm in diameter. Only twenty-eight of the patients had stones in the proximal ureter, while the remainder had renal stones. Stone volume as measured by CT was found to be the best predictor of stone-free status after ESWL relative to BMI, SSD, and maximum stone length. A stone volume of <500 mL best predicted treatment success ($p < 0.001$) with 72% of patients with a stone volume of <500 mL having a successful outcome, versus only 27% with a stone volume of >500 mL. Results were not reported for ureteral stones alone.

In the study by Shah et al. <#391>, 99 patients with solitary renal and upper ureteral stones were first separated into two groups: group A consisted of 42 patients with stones of attenuation value <1200 HU, while group B had 57 patients with stones of attenuation value >1200 HU. The mean total number of shocks required to sufficiently fragment the stones in groups A and B were 1317.1 +/- 345.3 and 1646.5 +/- 610.8, respectively ($p = 0.001$). Average stone size (as measured by CT) for groups A and B were both >=11.5mm. Additional SWL treatments were not required in patients of group A, but 14.03% patients from group B did require retreatment ($p < 0.0001$). Thus, SWL for upper urinary tract stones was significantly more effective for stones with lower attenuation value. Results were not reported for proximal ureter stones exclusively.

Perks et al. <#288> retrospectively reviewed clinical records of 76 consecutive patients undergoing SWL for solitary urinary calculi ranging from 5-20mm. After treatment, stones of patients rendered stone free had a lower median density compared to stones in patients with residual fragments and unchanged stones ($p = 0.04$). The stone-free rate for stones less than 1,000 HU was 46%, but only 17% for stones >1,000 HU ($p = 0.01$). Only 20 and 5 of these 76 calculi were located in the proximal or distal ureter, respectively, and all were at least 5mm in diameter.

Tealab et al. <#356> evaluated attenuation values for renal calculi in 50 patients. Forty-one patients (80%) subsequently underwent successful ESWL treatment. The clearance rate for stones with an attenuation value >1,000 HU was significantly lower than those with a value of less than 1,000 HU. Additionally, there was a relation between stone attenuation and chemical stone composition. Stones with higher calcium and phosphate contents displayed higher attenuation value and showed relative ESWL resistance with a higher ESWL failure rate. Stones with a lower calcium contents had lower attenuation values and were more successfully fragmented in a lower number of ESWL sessions. However, this study evaluated renal calculi only.

Yoshida et al. <#274> tested the predictive capability of different CT-based variables such as total stone volume (TSV), the mean attenuation value (MAV), and the attenuation value histogram on successful ESWL outcomes 62 subjects, but these were limited to patients with renal or proximal ureteral radiopaque stones greater than 5mm and less than 20mm. The TSV and MAV were significantly different statistically between treatment success and failure groups (P <0.001), but results were not stratified by location.

Strength of Evidence: The quality of this body of evidence is moderate (**level B**). These studies, though limited in number consistently report that CT attenuation values have an inverse relationship with ESWL success rate - the higher the attenuation, the less chance of success. Additional studies are likely needed to refine this evidence for the benefit of clinicians. However, as noted earlier by a panel member, no studies effectively studied smaller ureteral calculi (<5mm) located in the distal or middle ureter, suggesting a potential limitation of density measurements.

Five studies concentrated exclusively on the information gained from characterizing the chemical composition of ureteral calculi in vivo using CT imaging. Patel et al. <#351> investigated the efficacy of density measurements (in Hounsfield units) on CT to determine if it was possible to distinguish various calcium stone subtypes. They found HU measurement of urinary stones (>5mm and < 20mm) on CT may be used to separate some calcium stone subtypes, specifically calcium oxalate monohydrate (CaOMH) and calcium oxalate dihydrate (CaODH). This information may potentially be valuable to practitioners counseling patients on treatment options. The next three studies utilized low-dose dual-energy (DE) CT to determine stone composition in vivo. In each study, compositions predicted using imaging software were compared to biochemical analysis results of recovered stones. Thomas et al. <#358> found DE analysis was able to distinguish between calcified and non-calcified calculi in all 28 cases. In this study calculi ranged from 2mm to 12mm (mean 5mm), all of which were invasively extracted. Ascenti et al. <#365> correctly assigned chemical composition in all 24 sampled ureteral calculi including uric acid (n = 3), calcium salt (n = 18), and combined uric acid-calcium salt (n = 3) stones. These stones ranged in size from 3mm to 14mm (mean 8mm), and were located in the upper (7), middle (5), and lower ureter (12). Thomas et al. <#393> retrospectively evaluated the ability to differentiate urinary calculi of variable compositions. Their reported sensitivity/specificity for post-processing CT images across 40 subjects were: uric-acid calculi (100%/97%), cystine calculi (100%/97%), and calcified calculi (97%/100%). A single struvite calculus could not be distinguished from cystine. Due to mixed patient group descriptions, the sizes of these calculi could not be confirmed. However, the authors state that calculi with a diameter < 2 mm were excluded from the calculation of the dual-energy ratio by the analysis software because of expected domination of partial volume effects. Zilberman et al. <#398> used standard-dose DE CT with a comprehensive novel post-processing step to successfully discriminate among main subtypes of 82 urinary calculi in vivo. These stones were all renal calculi and ranged in size from 2.1mm to 11.9mm (mean 5.6mm).

Strength of Evidence: The quality of this body of evidence is moderate (**level B**). These studies consistently report reasonable accuracies when using CT technology to distinguish stone composition subtypes in vivo (particularly calcified vs. non-calcified). This information may have larger implications in determining appropriate clinical treatment of ureteral calculi. However, larger studies are needed to support the current body of evidence and clarify differences in accuracy among CT protocols. Additionally, few small ureteral stones were assessed in these studies, again suggesting a potential limitation to measuring stone composition via dual-energy CT.

The panel posed the question to what extent and for how long can ureteral obstruction be tolerated in a patient without risk of permanent renal damage or loss of function (GQ17). Through conversations with the panel, a time frame 3 to 6 weeks may be reasonable to allow for continuous obstruction in a patient with stone. One study was relevant to this particular question and long-term window. Hwang et al. <#375> evaluated 30 patients with impacted distal ureteral stones <5 mm using CT. Stones were defined as impacted if they were found to stay in the same location for at least 2 months (8 weeks). Ureteroscopic procedures demonstrated that impacted stones often had concurrent ureteral lesions such as severe mucosal edema, strictures, ureteral polyps, or submucosal stones. Severe edematous lesions were found adjacent to impacted stones in nine patients, ureteral strictures in five patients, ureteral polyps in four patients, and submucosal stones in one patient. Unfortunately there was no associated evaluation of renal function in these patients.

Strength of Evidence: The quality of this body of evidence is low (**level C**). This single study suggests that stones impacted for longer than two months are likely to have concurrent ureteral lesions.

In addition to secondary signs on CT, the panel was interested in the diagnostic accuracy of different imaging modalities based on stone location (GQ18). Fourteen associated studies were found.

Six studies reported CT accuracy <#097, 170, 217, 241, 235, 195> with perfect or near perfect sensitivity and specificity for all stone locations including the proximal, middle, and distal ureter. Two studies comparing CT to other modalities <#235, 195> concluded that CT was superior in accuracy compared to plain film KUB, US, or MRI regardless of location. One earlier study from 1990 by Levine and colleagues <#097> reported challenges to locate stones in the lower urinary tract, and concluded that to determine stones impacted at the ureterovesical junction from stones already passed into the bladder, a prone CT scan can be used to make this distinction rather than a supine scan.

Two studies reported location-based accuracies for IVP. Al-Hassan et al. <#006> performed a diagnostic accuracy study comparing US and IVP for 54 patients with suspected calculi. Forty-five stones were diagnosed in the following locations: distal – 31, proximal – 3, renal pelvis – 10, and uretrovescicle – 1. In this study, reported sensitivities for IVP by location were: 97% (distal), 66% (proximal), 70% (renal pelvis), and 100% (uretrovescicle). In contrast, reported sensitivities for US were: 13% (distal), 66% (proximal), 100% (renal pelvis), and 0% (uretrovescicle). A second article <#22> compared accuracy of stone detection for IVP compared to X-ray and US alone, and in combination (X-ray+US). Forty-four stones were evaluated in either the upper-middle ureter (n=32) or the vesicoureteral junction (n=12). Computed sensitivities by location and modality were: IVP/upper-middle: 100%, US/upper-middle: 9%, X-ray/upper-middle: 78%, US+X-ray/upper-middle: 78%, IVP/VUJ: 100%, US/VUJ: 67%, X-ray/VUJ: 75%, US+X-ray/VUJ: 83%. Both studies concluded that IVP is more accurate than ultrasound or plain X-ray independent of stone location.

Location-based results or comments for US accuracy were found in six additional studies <#005, 127, 252, 284, 369, 378>. Sensitivities for US in the distal ureter/UVJ tended to be higher than those for the proximal/middle ureter or ureteropelvic junction. However, there was considerable variability in the reported sensitivity for US across these studies. One study noted the potential difficulty for US to detect calculi in pregnant patients when located in the lower third of the ureter (deep in the pelvis).

Strength of Evidence: The quality of this body of evidence is moderate (**level B**). All articles assessing unenhanced CT accuracy or comparing it to other modalities consistently found CT to be the most accurate technology for stones independent of location. Reported accuracies for other modalities were less consistent across studies, particularly for US.

Guiding Question 19 sought to validate the reliability of hydronephrosis as an indicator of the degree of obstruction in patients with suspected ureteral calculi. In particular, if hydronephrosis was present and calculus was suspected, what is the best way to assess obstruction or loss of renal function? A total of 24 studies provided relevant information in the context of GQ19.

The majority of articles selected in this case (20 out of 24) evaluated the use of the resistive index (RI) or a similar measure to predict obstruction in patients. In 17 of these 20, IVP was used as the official gold standard (or at least part of the standard) to confirm obstruction. Computed tomography was used as the gold standard in two studies. The use of IVP as a consistent gold standard provides evidence that it is the most widely accepted imaging modality to confirm obstruction, however, many of these studies also found resistive indices to be a potential alternative to IVP. As the most common approach in these studies, renal RI was measured by ultrasonography for the left and right kidneys in each patient, and change in resistive index between ipsilateral and contralateral kidneys was calculated (dRI). Threshold values for RI and dRI measurements were employed to classify a patient as obstructed (or not), and corresponding sensitivities and specificities were calculated relative to a reference standard. Although statistically significant differences in RI were often found between ipsilateral and contralateral kidneys, this did not always translate into an accurate classification rule for obstruction. Using absolute RI measurements, reported sensitivities for obstruction ranged from 44-94%, while specificities ranged from 55-98%. The change in resistive index relative to the contralateral kidney (dRI) tended to perform better as a measure for obstruction, but again there was significant variability in reported sensitivity/specificity.

Two studies <#15, 70> used IVP as the gold standard in diagnosing obstruction in patients with symptoms of ureteral colic. In both studies, the authors concluded that IVP was not critical for routine evaluation of patients with initial presentation of symptoms. One study proposed the replacement of IVP with a combination of US and X-ray, while the second study stated that IVP should be utilized if a patient's symptoms remain after treatment.

Two studies <#158, 170> employed nuclear medicine imaging as the gold standard to assess obstruction in patients with renal colic. Both studies ultimately concluded that nuclear medicine was preferable to non-contrast CT in determining the degree of obstruction.

Strength of Evidence: The quality of this body of evidence is moderate (**level B**). The use of IVP as the gold standard in the large majority of studies assessing renal indices for predicting obstruction indicates that it is widely accepted as the most practical modality for this purpose. While renal index measurements do provide statistically significant information about obstruction in the overall patient population, the choice of threshold for classifying obstruction from non-obstruction, as well as absolute RI versus change in RI, results in variability in the reported sensitivity and specificity.

Another Guiding Question was whether lack of hydronephrosis properly excluded clinically important obstruction after ureteroscopy or ESWL (GQ20). Two case series were found to be relevant:

Shigeta et al. <#101> followed 161 patients treated with ESWL in order to determine reasons why residual fragments failed to clear. Of the 161 patients, 14 had ureteral calculi and 147 had renal calculi, and all patients were imaged at three months using IVP and X-ray after ESWL. At three months follow-up, 55 patients were positive for hydronephrosis on IVP. Of the remaining 106 patients who lacked hydronephrosis at follow-up, 85 (80.2%) did not successfully pass their residual fragments. The authors state that this high proportion indicates additional unknown factors are associated with failure with clearance residual fragments after ESWL.

Ciftci et al. <#367> prospectively evaluated 20 patients with residual stone after ESWL treatment using Doppler ultrasound. All 20 patients with residual stone had some level of hydronephrosis, but of varying degrees. On US examination, six, nine, and five patients had severe, moderate and mild hydronephrosis, respectively. Therefore 25% of patients in this study had mild hydro. Although no subjects lacked hydronephrosis completely, the proportion of patients with mild hydronephrosis suggests that if the hydronephrosis was not obvious it may be missed, and this would have implication for patient outcomes.

Strength of Evidence: The quality of this body of evidence is low (**level C**). While further studies are needed, the results of these studies indicate that a lack of hydronephrosis does not necessarily exclude a patient from clinically important residual obstruction after ESWL.

Risks and Harms

A total of eight Guiding Questions were related to the potential risks and harms associated with different imaging modalities for diagnosis and management of urolithiasis (GQs 21-28). The searches identified no studies addressing the potential risks or harms of magnetic resonance imaging (GQ27) in patients with urolithiasis.

Literature searches identified 26 studies that addressed the risks and harms associated with non-contrast CT (GQ21, GQ23). There were a large number of articles that cited the importance of mitigating radiation dose during CT scans, however, only the studies we chose provided concrete quantifiable information regarding relative differences between non-contrast CT and other modalities as well as dose measurements.

Conventional standard-dose CT was the primary modality discussed in 13 relevant articles, most of which reported quantifiable levels of exposure for patients undergoing CT. In recent years, a number of groups have modified their standard CT procedures to reduce the radiation exposure to patients with symptoms of renal colic. In 10 of the selected articles, low-dose CT protocols were examined. The diagnostic accuracy of these alternative protocols is discussed above, but in this section the corresponding radiation dose measurements are relevant. Table 3 provides a description of the exposure for each study employing either a standard-dose or low-dose CT protocol. The low-dose protocols report much lower levels of radiation exposure for patients than typical standard-dose CT, often near or even below expected levels of conventional radiography or an IVP procedure.

Three articles were not related to CT radiation dose concerns but rather diagnostic accuracy. Schwartz et al. <#100> performed a retrospective study of records from 36 patients prescribed indinavir sulfate and presenting with renal colic. Indinavir sulfate is a protease inhibitor utilized for HIV antiviral therapy with poor solubility and significant urinary excretion. This study found none of the indinavir-based calculi could be detected by non-contrast CT.

A study by Zilberman and colleagues <#398> studied the characterization of urinary stone composition in vivo using dual energy CT. While the use of dual energy CT was found to accurately discriminate among main subtypes of urinary calculi in vivo, the authors point out that attenuation profiles alone were insufficient to reliably distinguish between certain subgroups of calcium containing renal stones, in particular calcium oxalate monohydrate, calcium oxalate dehydrate or calcium phosphate. This limitation represents a significant drawback to predicting stone composition with attenuation profiles, as stone fragility varies considerably between calcium compositions during ESWL.

Lastly, a study by Kishore et al. <#316> assessed the accuracy of CT-based measurements of ureteral stone size (e.g. largest diameter) in 41 patients who were able to pass a known stone spontaneously and intact. Ultimately, the authors determined that non-contrast CT imaging is a poor predictor of the largest stone dimension for distal ureteral calculi. Therefore, practitioners should take caution when considering CT measurements of stone size to counsel patients on the rate of spontaneous stone passage.

Strength of Evidence: The majority of these studies were diagnostic accuracy trials or case-series with limited focus on risks and harms of non-contrast CT. Additionally there is substantial variability in estimates of radiation exposure across studies. Therefore the quality of this evidence base is low (**level C**).

Table 3. Reported non-contrast CT radiation exposure levels.

Article_UID	Authors	CT protocol	Cumulative CT radiation description
085	Vieweg J;Teh C;Freed K;Leder RA;Smith RH;Nelson RH;Preminger GM;	Standard	Skin entry dose delivered in helical CT (3 to 5 rad) is equivalent to 10 to 20 plain film images
086	Yilmaz S;Sindel T;Arslan G;Ozkaynak C;Karaali K;Kabaalioglu A;Luleci E;	Standard	Skin dose of spiral CT was calculated to be approximately three times higher than that of IVP (unless extra films are taken during IVP)
093	Denton ER;MacKenzie A;Greenwell T;Popert R;Rankin SC;	Standard	CT protocol average effective dose of 4.7 mSv
125	Rosser CJ;Zagoria R;Dixon R;Scurry WC;Bare RL;McCullough DL;Assimos DG;	Standard	Helical CT radiation dose equivalent in this study was 180 mrem (1.8 mSv)
138	Homer JA;vies-Payne DL;Peddinti BS;	Standard	Average effective radiation dose for CT was calculated to be 4.95 mSv
197	Mendelson RM;rnold-Reed DE;Kuan M;Wedderburn AW;Anderson JE;Sweetman	Standard	Total effective dose was calculated to be 5.004 mSv for women and 3.55 mSv for men

	G;Bulsara MK;Mander J;		
265	Katz SI;Saluja S;Brink JA;Forman HP;	Standard	Mean effective doses for a single study were 6.5 mSv for single-detector CT and 8.5 mSv for multi-detector CT. A small but significant subset of the patient population (4%) was estimated to receive from 20 mSv to as high as 154 mSv because of the repetitive use of CT to evaluate acute flank pain.
277	Chowdhury FU;Kotwal S;Raghunathan G;Wah TM;Joyce A;Irving HC;	Standard	Estimated radiation dose of CT to be 3.2-5.3 mSv
278	Eikefjord EN;Thorsen F;Rorvik J;	Standard	Mean effective CT radiation dose was 7.7 mSv
312	John BS;Patel U;Anson K;	Standard	Median total effective dose in patients who had CT was 14.46 mSv.
332	Alshamakhi AK;Barclay LC;Halkett G;Kukade G;Mundhada D;Uppoor RR;Gawai P;	Standard	Average estimated CT radiation dose to the patient was 11.89 mGy
350	Passerotti C;Chow JS;Silva A;Schoettler CL;Rosoklija I;Perez-Rossello J;Cendron M;Cilento BG;Lee RS;Nelson CP;Estrada CR;Bauer SB;Borer JG;Diamond DA;Retik AB;Nguyen HT;	Standard	CT radiation dose of 10 mGy
371	Goldstone A;Bushnell A;	Standard	10 mSv per abdominal CT scan
119	Liu W;Esler SJ;Kenny BJ;Goh RH;Rainbow AJ;Stevenson GW;	Low-dose	2.8 mSv for helical CT of the abdomen
146	Meagher T;Sukumar VP;Collingwood J;Crawley T;Schofield D;Henson J;Lakin K;Connolly D;Giles J;	Low-dose	Average radiation dose of 3.5 mSv for CT

172	Hamm M;Knopfle E;Wartenberg S;Wawroschek F;Weckermann D;Harzmann R;	Low-dose	Low-dose protocol was 1.5 mSv and 0.98 mSv for women and men respectively
203	Tack D;Sourtzis S;Delpierre I;De M;Gevenois PA;	Low-dose	Mean effective radiation dose was 1.2 mSv (range 0.8–1.5 mSv) in men and 1.9 mSv (range 1.5–2.3) in women
266	Kluner C;Hein PA;Gralla O;Hein E;Hamm B;Romano V;Rogalla P;	Low-dose	Mean effective whole-body dose for low-dose CT was 0.7 mSv for women and 0.5 mSv for men, with a reproductive organ dose of 1.1 mSv for women.
268	Poletti PA;Platon A;Rutschmann OT;Verdun FR;Schmidlin FR;Iselin CE;Vermeulen B;Sarasin FP;Buhler LH;Becker CD;	Low-dose	Mean effective dose for low-dose CT alone was 3.5 mSv
286	Mulkens TH;Daineffe S;De Wijngaert R;Bellinck P;Leonard A;Smet G;Termote JL;	Low-dose	Mean effective dose was 1.41-1.58 mSv for low-dose examinations.
297	White WM;Zite NB;Gash J;Waters WB;Thompson W;Klein FA;	Low-dose	Low-dose CT mean radiation exposure was 705.75 mrads, while prior standard-dose CT exposure was 2500 mrads
365	Ascenti G;Siragusa C;Racchiusa S;Ielo I;Privitera G;Midili F;Mazziotti S;	Low-dose	Mean effective dose per patient was 2.6 mSv and ranged between 1.89 and 3.7 mSv
393	Thomas C;Heuschmid M;Schilling D;Ketelsen D;Tsiflikas I;Stenzl A;Claussen CD;Schlemmer H;	Low-dose	Estimated average radiation dose of 2.7mSv

Additionally, literature searches identified two studies that described risks associated with nuclear medicine studies (GQ22, GQ28) <#002 and #014>. Both of these articles focused on nuclear scintigraphy (specifically Technetium-99m DTPA) in the evaluation of renal colic and had similar patient group sizes (40 and 36 patients for #002 and #014, respectively). With regard to risk, Brown et al. reported that the radiation dose per patient was 15 mCi (555 MBq), while the protocol of Embon et al. had an exposure of 4-7 mCi (148-259 MBq) for each patient.

Strength of Evidence: The quality of this evidence base is low due to the limited number of relevant studies (**level C**).

Two studies were found that addressed the risks and harms associated with conventional radiography (GQ24). One study comparing the utility of different imaging modalities in patients with ureteric colic reported that the radiation exposure delivered by their plain film KUB protocol was 0.57 mSv <#022>. One additional study determined the accuracy of accident and emergency (A&E) doctors' diagnosis of radiopaque ureteric calculi on plain abdominal radiographs <#042>. Ultimately, they found that radiologists were significantly more accurate at identifying radiopaque calculi on plain films than A&E doctors (P = 0.0011).

Strength of Evidence: The quality of this evidence base is low due to a lack of related articles (**level C**).

Literature searches identified 11 studies that addressed the risks and harms associated with intravenous pyelography (GQ25). Nine articles reported mean or median radiation doses calculated for patients who received IVP imaging. Cumulative radiation doses per patient ranged from a minimum of 0.59 mSv to a maximum of 4.83 mSv (see Table 4).

Harmful reaction to intravenous contrast medium is also a reported risk for IVP. Wendt-Nordahl et al. <#273> evaluated the frequency of adverse events and possible risk factors after the administration of iobitridol in a large multicenter surveillance study. Of the 49,975 patients given contrast for urography, only 0.9% experienced acute adverse events that were non-serious and less than 0.1% of patients experienced vomiting, dizziness or other cardiovascular problems. A single patient developed an anaphylactic shock but recovered fully. Significantly more females had contrast-related symptoms relative to men, and adverse reactions were significantly more likely in patients with pre-existing renal insufficiency or allergies. Patients undergoing urography for ureteral calculi had significantly fewer symptoms compared to patients with other indications. The authors concluded that iobitridol is clinically safe and well tolerated in urography; however, caution is advised when administering iobitridol to high-risk patients. One additional related study <#325> described complications in two out of fifteen patients (13%) who were administered ionic contrast media and had minor allergic reactions in the form of transient rashes and itching.

Strength of Evidence: The quality of this evidence base is low (**level C**). The variability of radiation exposure measurements to patients suggests that (i) IVP protocols for patients with suspected or confirmed urolithiasis vary considerably, and (ii) overall radiation dose is protocol and patient dependent, and therefore difficult to precisely quantify. Adverse reactions to contrast medium is a concern, but the large multicenter study discussed above found that patients undergoing IVP for urolithiasis had fewer symptoms than other patients.

Table 4. Reported IVP radiation exposure levels.

Article_UID	Authors	Cumulative IVP radiation description
022	Dalla PL;Stacul F;Bazzocchi M;Pagnan L;Festini G;Marega D;	Approximately eight exposures were performed with a cumulative radiation dose of 4.83 mSv.
093	Denton ER;MacKenzie A;Greenwell T;Popert R;Rankin SC;	A 3-film IVP gave an average dose of 1.5 mSv.
119	Liu W;Esler SJ;Kenny BJ;Goh RH;Rainbow AJ;Stevenson GW;	1.33 mSv for the IVU examination.
125	Rosser CJ;Zagoria R;Dixon R;Scurry WC;Bare RL;McCullough DL;Assimos DG;	Radiation dose was 189 mrem (1.89 mSv) and 392 mrem (3.92 mSv) for women.
138	Homer JA;vies-Payne DL;Peddinti BS;	The average IVP dose was 1.48 mSv with a range of 0.59-2.71 mSv.
146	Meagher T;Sukumar VP;Collingwood J;Crawley T;Schofield D;Henson J;Lakin K;Connolly D;Giles J;	1.5 mSv for an average 5-film IVU.
197	Mendelson RM;rnold-Reed DE;Kuan M;Wedderburn AW;Anderson JE;Sweetman G;Bulsara MK;Mander J;	Median total effective dose for the IVP examinations was calculated to be 2.97 mSv.
278	Eikefjord EN;Thorsen F;Rorvik J;	Mean effective dose for IVP was 3.63 mSv.
401	Fowler JC;Cutress ML;Abubacker Z;Saleemi MA;Alam A;Shekhdar J;Wagstaff H;	The effective dose for each IVP film taken was 0.5 mSv. The number of IVP films was variable, ranging from 2-6 films per patient, with a mean of 2.8 films, and a

		corresponding effective dose of 1.4 mSv (range 1.0-3.0 mSv).

One study was marginally related to risks and harms associated with ultrasound (GQ26). In an attempt to improve the diagnostic accuracy of ultrasound imaging for detection of ureteral stones, patients were prepared by fasting for 8 hours, and then had their bladder filled by an intravenous drip infusion of normal saline with an infusion rate less than 1000mL/s <#321>. It was not clear if this approach is standard in practice. And though this procedure led to improved accuracy (98.3% sensitivity / 100% specificity), the required preparation time may be considered a risk to some patients with severe obstruction.

Strength of Evidence: The quality of this evidence base is low (**level C**).

Utilization and Cost

The final three Guiding Questions were related to the cost and utilization of different modalities for imaging and management of ureteral calculus disease (GQs 29-31). Due to our prioritization of articles for full text review, a limited number of studies were relevant to these questions.

The panel posed a question regarding the economic consequences of using particular imaging modalities (GQ29). Although this topic was not prioritized, the literature review selected six studies that provided some information in this context.

In 1996, Smith et al. <#054> performed one of pioneering diagnostic accuracy trials of CT for detecting ureteral calculi. They noted in their closing statements that in their institution, the charge for a CT scan to evaluate flank pain and that of IVP were equivalent. Farres et al. <#112> utilized MRI technology to investigate patients with urological disorders including urolithiasis. Overall they conclude that MRI is significantly more expensive than other modalities, but can provide critical information that may prevent a need for even more expensive invasive procedures. Sudah et al. <#151> also concluded that MRI has a high cost. At their institution, the calculated cost of contrast-enhanced MR urography was approximately $500, compared with $97 for excretory urography and $185 for unenhanced CT.

Mendelson et al. <#197> performed a cost assessment of IVP versus unenhanced CT for investigation of suspected renal colic. The authors found the excess cost of an unenhanced CT examination over IVP was calculated at $15.46 (Australian) per examination. No significant difference in the length of hospital stay or the rate of intervention was demonstrated between patients imaged with CT or IVP. In addition, averaging the costs of additional imaging during and post-admission over the groups as a whole leads to the calculation of the total excess cost of performing a CT compared to an IVP in this study to be $25.64 (Australian).

Kennish et al. <#315> evaluated whether a plain film KUB was necessary prior to CT in patients presenting with acute flank pain. Ultimately, they concluded that an initial X-ray was redundant when CT was utilized, and that there were significant cost savings at their institution when plain films were eliminated as part of the initial assessment.

Routh et al. <#389> performed a large-scale retrospective review of pediatric patients with urolithiasis. They noted an increasing trend of CT utilization for these pediatric patients, and found that with respect to cost, patients with a CT had higher median hospital costs than patients without CT ($2,051 vs.

$1,759). CT use was associated with older patient age, nonwhite race and public insurance. The hospital where a patient receives treatment was the single most important feature driving CT and surgery use. Patient age, race and insurance status had a smaller but significant role.

Strength of Evidence: The quality of this evidence base is low (**level C**).

Eight studies were found to provide information about trends in utilization of different imaging modalities in the management of initial episodes of ureteral colic (GQ30).

Gottlieb et al. <#171> retrospectively assessed changes in examination patterns since the introduction of unenhanced CT for evaluation of patients presenting to the emergency department with symptoms of urinary tract calculi. Over a three year period (1997, 1998, 1999), the authors saw a dramatic increase in the number of CT exams per patient visit: in 1997, CT was used in 25 of 291 visits (8.6%), but in 1999 CT was used in 593 of 659 visits (90%). Moreover, there was a significant reduction in IVP usage: in 1997 IVP was used 155 of 291 visits (53.5%), but by 1999 IVP was only used in 17 of 659 visits (2.6%). Additionally, the total number of imaging studies increased by 26.7% per patient visit. In this institution the use of imaging for potential urolithiasis increased markedly since the introduction of unenhanced CT, and CT effectively replaced IVP as the modality for imaging patients with suspected calculi.

Kirpalani and colleagues <#247> also assessed changes in imaging patterns in their emergency department for patients presenting with symptoms of renal colic from July 1998 through December 2002. During the 6-month study period in 1998, 179 CT examinations were performed in symptomatic patients. During the same period in 2002, 234 CT examinations were performed. After correcting for the total number of visits, it was determined that there was a relative increase of 21.3% in number of CT examinations performed in the emergency department. A total of 117 (65.4%) of 179 CT studies in 1998 and 153 (65.4%) of 234 CT studies in 2002 demonstrated renal calculus disease.

In 2005, Otite et al. <#251> aimed to study imaging utilization trends within the UK using a widely distributed survey to 548 consultant urologists working in the UK and the Republic of Ireland. Two hundred and ninety-three consultants (54%) from 171 institutions returned their questionnaires. IVP was used in the majority of institutions (146; 85.4%) for investigating acute flank pain. Only 18 (10.5%) used CT, while 4.1% used ultrasonography. Among those using IVP as the investigation of choice, the main reason given was limited CT services (82.4%). Others included familiarity with IVP features (51.2%), limited availability of radiologists for out-of-hours reporting of CT (26%), more rapid procedure (20.8%), lower cost (20%), and lower radiation exposure (19.6%). Only 52.4% of consultants using IVP stated they would prefer CT if both were equally available.

Brown <#259> used data from the 2000 National Hospital Ambulatory Medical Care Survey to study diagnostic and treatment patterns for renal colic in USA emergency departments. In this large-scale retrospective review, there were a total of 1,139,257 visits documented with a primary ED diagnosis of renal calculus or colic. In 53% of patients no radiological test was performed, and 25% of patients had a CT scan. Only 5% of patients had an ultrasound performed. 22% of patients had a plain x-ray other than chest.

Cupisti et al. <#303> reported diagnostic trends for suspected renal colic at the University of Pisa emergency department in 2005. In this retrospective study, there were a total of 70,621 visits in 2005. Renal colic or stone was diagnosed in 696 cases (1%). Ultrasonography was the only examination in 70.2% of cases, and it was coupled with plain abdominal X-ray (KUB) in 10% of cases. The authors state that during 2005, CT was not used as the first and only imaging modality in cases of renal colic, and that this different diagnostic approach may be linked to financial and cultural reasons.

Ahmed et al. <#364> was a study of IVP and CT utilization for evaluation of flank pain from January 1, 2002 until December 31, 2007 in a tertiary care university hospital. In the pediatric population, very limited numbers of CT scans were undertaken ranging from 3 to 20 scans per year with a mean of 10 scans. In the adult group, however, there was a significant change seen during the study period with a rise in CT and corresponding decline in IVP referrals. The year-wise distribution of respective numbers of CT and IVP procedures were 423 (26%) and 1263 (74%) in year 2002; 627 (38%) and 1025 (62%) in year 2003; 1023 (53%) and 892 (47%) in year 2004; 1217 (63%) and 699 (37%) in year 2005; 1469 (72%) and 580 (28%) in year 2006, and finally 1571 (77%) and 456 (23%) in year 2007. Both Pabon-Ramos et al. <#387> and Routh JC and colleagues <#389> also concluded that in the evaluation of patients with flank pain, IVP procedures have declined while CT scans have increased.

Strength of Evidence: The quality of this evidence base is high (**level A**). These large-scale retrospective studies consistently report an increase in utilization of CT as the primary imaging modality in the evaluation of patients with suspected urolithiasis. The increase in CT usage has caused a corresponding decrease in the utilization of IVP. It should be noted that in some institutions, a lack CT-availability will prevent some practitioners from using this modality.

The final Guiding Question posed by the panel was on the topic of follow-up imaging frequency after diagnosis of ureteral calculus disease (GQ31). Although this topic was not the particular emphasis of any study reviewed, a total of 27 studies offered some information that may be beneficial for crafting the panel's recommendations.

Two studies <#015, 138> described their frequency of imaging follow-up after calculus diagnosis without intervention. Haddad et al. <#015> performed a diagnostic accuracy study on 101 consecutive patients with renal colic who were evaluated with US followed immediately by IVP. Recorded symptom duration was 2 hours to 3 days with the majority of patients presenting at 2 to 24 hours. Patients diagnosed with ureteral obstruction were admitted to the hospital and followed up with serial US exams every 48 hours for up to one week and at 3-month intervals after discharge. The second non-invasive study by Homer and colleagues <#138> evaluated 228 patients with suspected calculi, diagnosing 159 with stones. Documented imaging follow-up was radiological workup at 3-4 weeks.

The remaining 25 studies described follow-up imaging protocols after some form of intervention for calculus disease including SWL, PCNL, Ho:YAG laser ureterolithotripsy, ureteroscopic lithotripsy, and ureteroscopy. There was substantial variability in the details of these follow-up protocols as well as timing and choice of imaging modality. Therefore, we present the information from each study in Table 5. Overall, three general timeframes for imaging appear consistent following a procedure: immediately after the procedure, a short-term window to identify potential complications, and a long-term window to determine treatment success. In Table 5, the immediate imaging was typically within 24-48 hours after intervention completion and consisted of a KUB plain film and/or ultrasound. The short-term window of follow-up imaging ranged from 1-2 weeks after intervention (perhaps periodically) and also tended to utilize KUB plain film and/or ultrasound. The long-term general timeframe ranged from six to 12 weeks and often employed a more thorough imaging modality such as CT or IVP.

Strength of Evidence: The quality of this evidence base is moderate (**level B**). There are some definite trends in reported follow-up imaging frequency after intervention, and hopefully this information will assist the panel with its recommendations.

Table 5. Follow-up imaging descriptions for 25 intervention-based studies identified in the literature review.

Article UID	Authors	Title	Year	Journal	Primary intervention	Follow-up imaging description
019	Srivastava A;Ahlawat R;Kumar A;Kapoor R;Bhandari M;	Management of impacted upper ureteric calculi: results of lithotripsy and percutaneous litholapaxy	1992	British Journal of Urology	SWL or PCNL	For ESWL: Patients were followed up 2 weeks after the procedure and then 4 and 6 weeks later, with plain abdominal X-ray. Fragments > 5 mm were treated similarly during follow-up visits. For PCNL: A plain abdominal X-ray and nephrostogram were performed after 48 to 72 h, prior to removing the nephrostomy tube and catheter. For all patients, IVP was performed 3 months post-operatively to assess clearance and functional status.
029	Farsi HM;Mosli HA;Alzimaity M;Bahnassay AA;Ibrahim MA;	In situ extracorporeal shock wave lithotripsy for primary ureteric calculi	1994	Urology	SWL	Follow-up evaluation consisted of a KUB plain film immediately after the treatment and one week later. An intravenous urogram was done three months after completion of the treatment.
030	Kumar A;Kumar RV;Mishra VK;Ahlawat R;Kapoor R;Bhandari M;	Should upper ureteral calculi be manipulated before extracorporeal shock wave lithotripsy? A prospective controlled trial	1994	The Journal of urology	SWL	X-ray if necessary at 4, 15, and 30 days post-ESWL treatment. IVP at 3 months to assess clearance rates.
035	Robert M;Delbos O;Guiter J;Grasset D;	In situ piezoelectric extracorporeal shock wave lithotripsy of ureteric stones	1995	British Journal of Urology	SWL	Plain X-ray after 1 month

041	Bon D;Dore B;Irani J;Marroncle M;Aubert J;	Radiographic prognostic criteria for extracorporeal shock-wave lithotripsy: a study of 485 patients	1996	Urology	SWL	Final treatment results were evaluated at 3 months with IVP, plain x-ray tomography, and renal ultrasound.
084	Takahashi N;Kawashima A;Ernst RD;Boridy IC;Goldman SM;Benson GS;Sandler CM;	Ureterolithiasis: can clinical outcome be predicted with unenhanced helical CT?	1998	Radiology	Surgical intervention	Radiography or IVP used for follow-up imaging - frequency not detailed.
199	Pareek G;Armenakas NA;Fracchia JA;	Hounsfield units on computerized tomography predict stone-free rates after extracorporeal shock wave lithotripsy	2003	Journal of Urology	SWL	Six weeks after treatment, plain x-ray was used to assess treatment efficacy.
236	Sinha M;Kekre NS;Chacko KN;Devasia A;Lionel G;Pandey AP;Gopalakrishnan G;	Does failure to visualize the ureter distal to an impacted calculus constitute an impediment to successful lithotripsy?	2004	Journal of endourology / Endourological Society	SWL	Plain KUB radiography twice weekly
246	Kilic S;Altinok MT;Ipek D;Beytur A;Baydinc	Color Doppler sonography examination of partially obstructed	2005	International Journal of	PCNL	US at postoperative days 1, 7, and 30

	YC;Gunes G;	kidneys associated with ureteropelvic junction stone before and after percutaneous nephrolithotripsy: preliminary report		Urology		
270	Seitz C;Fajkovic H;Remzi M;Waldert M;Ozsoy M;Kramer G;Marberger M;	Rapid extracorporeal shock wave lithotripsy treatment after a first colic episode correlates with accelerated ureteral stone clearance	2006	European Urology	SWL	X-ray, US every 2 weeks up to 3 months or after each stone passage
288	Perks AE;Gotto G;Teichman JMH;	Shock Wave Lithotripsy Correlates With Stone Density on Preoperative Computerized Tomography	2007	Journal of Urology	SWL	CT, US or X-ray at 4 weeks and 3 months.
311	Hsiao HL;Huang SP;Wu WJ;Lee YC;Li WM;Chou YH;Chang AW;Huang CH;Sun SC;Liu CC;	Impact of hydronephrosis on treatment outcome of solitary proximal ureteral stone after extracorporeal shock wave lithotripsy	2008	The Kaohsiung journal of medical sciences	SWL	The post-ESWL radiographic evaluation included KUB and ultrasonography every 4-6 weeks for at least 3 months to assess the effectiveness of the treatment.

313	Juan YS;Huang CH;Wang CJ;Chou YH;Chuang SM;Li CC;Shen JT;Wu WJ;	Predictive role of renal resistance indices in the extracorporeal shock-wave lithotripsy outcome of ureteral stones	2008	Scandinavian journal of urology and nephrology	SWL	X-ray and US at 1 month
324	Seitz C;Memarsadeghi M;Fajkovic H;Tanovic E;	Secondary signs of non-enhanced CT prior to laser ureterolithotripsy: is treatment outcome predictable?	2008	Journal of endourology / Endourological Society	Ho: YAG laser uretero-lithotripsy	X-ray and US were performed on the first post-operative day.
327	Sighinolfi MC;Micali S;De Stefani S;Saredi G;Mofferdin A;Grande M;Bianchi G;	Noninvasive management of obstructing ureteral stones using electromagnetic extracorporeal shock wave lithotripsy	2008	Surgical endoscopy	SWL	Follow-up assessment, performed at 24 and 72 h, included radiologic and ultrasound examinations with renal function serum assessment.
341	Hong YK;Park DS;	Ureteroscopic lithotripsy using Swiss Lithoclast for treatment of ureteral calculi: 12-years experience	2009	Journal of Korean medical science	Ureteroscopic lithotripsy	Plain KUB radiography was performed 2 weeks after surgery to assess residual stone fragments.
346	Macejko A;Okotie OT;Zhao LC;Liu J;Perry	Computed tomography-determined stone-free rates for	2009	Journal of endourology /	Ureteroscopy	Follow-up CT at 12 weeks on average after ureteroscopy.

	K;Nadler RB;	ureteroscopy of upper-tract stones		Endourological Society		
354	Salem HK;	A prospective randomized study comparing shock wave lithotripsy and semirigid ureteroscopy for the management of proximal ureteral calculi	2009	Urology	Ureteroscopy/ SWL	X-ray and US were used two weeks are treatment to assess SFRs. The postoperative image protocol for every patient included biweekly KUB and US, with intravenous pyelography after 3 months to monitor the recovery of hydronephrosis and stone passage.
361	Youssef RF;El-Nahas AR;El-Assmy AM;El-Tabey NA;El-Hefnawy AS;Eraky I;El-Kenawy MR;El-Kappany HA;Sheir KZ;	Shock Wave Lithotripsy Versus Semirigid Ureteroscopy for Proximal Ureteral Calculi (<20 mm): A Comparative Matched-pair Study	2009	Urology	Ureteroscopy/ SWL	Abdominal radiography was performed the morning after URS to exclude the presence of residual stones. All treated patients were finally evaluated at 3 months after treatment by plain abdominal radiography to assess the stone-free status and by renal ultrasonography to evaluate the hydronephrosis.
372	Griffin SJ;Margaryan M;Archambaud F;Sergent-Alaoui A;Lottmann HB;	Safety of shock wave lithotripsy for treatment of pediatric urolithiasis: 20-year experience	2010	The Journal of urology	SWL	US and plain abdominal radiograph after a SWL treatment and 24 to 48 hours after treatment. Further evaluation at 1 and 3 months after treatment and annually thereafter.

382	Kumar A;Mohanty NK;Jain M;Prakash S;Arora RP;	A prospective randomized comparison between early (<48 hours of onset of colicky pain) versus delayed shockwave lithotripsy for symptomatic upper ureteral calculi	2010	Journal of endourology / Endourological Society	SWL	Stone fragmentation and clearance was assessed with KUB radiography the next day after each SWL session. Also, CT for 3-month follow-up.
391	Shah K;Kurien A;Mishra S;Ganpule A;Muthu V;Sabnis RB;Desai M;	Predicting effectiveness of extracorporeal shockwave lithotripsy by stone attenuation value	2010	Journal of endourology / Endourological Society	SWL	X-ray and US performed at regular intervals to assess fragmentation and clearance. For the purpose of the study, final clearance was judged at 3 months after SWL.
394	Turunc T;Gonen M;Kuzgunbay B;Bilgilisoy UT;Dirim A;Tekin MI;Ozkardes H;	The effects of hydronephrosis and stone burden on success rates of shockwave lithotripsy in pediatric population	2010	Journal of Endourology	SWL	A plain KUB film was obtained on the first day to assess the extent of stone fragmentation. If no fragmentation was seen, a second session was planned. If fragmentation was achieved, the patients were examined with KUB radiograph film 1 to 2 weeks later, and an additional session was planned when needed. All patients underwent IVU or non-contrast CT approximately 3 months after the last SWL session.
395	Turunc T;Kuzgunbay B;Gul U;Kayis AA;Bilgilisoy UT;Aygun C;Ozkardes H;	Factors affecting the success of ureteroscopy in management of ureteral stone diseases in children	2010	Journal of endourology / Endourological Society	Ureteroscopy	Follow-up was immediate (1 day) with X-ray, or follow-up imaging consisted of renal ultrasonography and abdominal plain radiography, with additional imaging (IVU, non-contrast CT) in patients in whom there was increased suspicion of residual or recurrent stone burden.

410	Wiesenthal JD;Ghiculete D;Ray AA;Honey RJD';Pace KT;	A clinical nomogram to predict the successful shock wave lithotripsy of renal and ureteral calculi	2011	Journal of Urology	SWL	X-ray KUB follow-up two weeks after treatment

References not assigned UIDs

American College of Radiology: ACR Appropriateness Criteria for Acute Onset Flank Pain — Suspicion of Stone Disease (2011). [Available online] http://www.acr.org/ac

Irving SO, Calleja R, Lee F, Bullock KN, Wraight P, et al. (2000) Is the conservative management of ureteric calculi of > 4 mm safe? BJU international 85: 637-640.

Kelleher JP, Plail RO, Dave SM, Cunningham DA, Snell ME, et al. (1991) Sequential renography in acute urinary tract obstruction due to stone disease. British Journal of Urology 67: 125-128.

Miller OF, Kane CJ (1999) Time to stone passage for observed ureteral calculi: a guide for patient education. The Journal of Urology 162: 688-690; discussion 690-681.

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Weizer AZ, Auge BK, Silverstein AD, Delvecchio FC, Brizuela RM, et al. (2002) Routine postoperative imaging is important after ureteroscopic stone manipulation. The Journal of Urology 168: 46-50.

Guidelines for Imaging of Ureteral Calculi

Appendices

March 07, 2012

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Supplementary Tables

Appendix A. Key Questions Created by the Panel

Key Question 1. What imaging modalities are necessary and effective in the diagnosis, management and follow up of ureteral calculus disease?

1. Of what value are location of pain and duration of pain in predicting imaging findings?

2. Once a stone is identified on CT, can size, shape, location or attenuation coefficient predict outcome?

3. Can low KV-MA studies perform as well as standard non-contrast CT?

4. Can conventional radiography plus/minus ultrasound perform as well as CT?

5. Can ultrasound be used as the primary diagnostic tool in properly prepared patients?

6. What is the diagnostic significance of hydronephrosis on ultrasound in the setting of ureteral colic?

7. What is the significance of extravasation in predicting clinical outcome?

8. Under what circumstances is a functional study required when following a known calculus using KV-MA, IVP, or CT?

Key Question 2: What are the potential clinical benefits, risks, and harms associated with imaging for ureteral calculus disease?

1. What is current utilization of CT in management of initial episode of ureteral colic? What are the average number of exams per episode?

2. What is the necessary interval of follow up imaging after initial diagnosis?

3. If hydronephrosis is confirmed and calculus is suspected, what is the best way to assess obstruction/potential loss of renal function? (Resistive indices, IVP, etc.)

4. How long can a patient with suspected high grade obstruction be observed without the risk of permanent renal damage?

Key Question 3: What is the most beneficial and cost-effective strategy for the follow-up of patients undergoing therapy for ureteral calculus disease?

1. What is the necessary interval of follow up imaging after ureteroscopic surgical removal?

2. What is the necessary interval of follow up imaging after *extracorporeal shock wave lithotripsy*?

3. What is the necessary interval of follow up imaging after medical explusive therapy?

Appendix B. Guiding Questions Addressed in Evidence Report

Supplementary Table 1. Guiding Questions and associated evidence.

Guiding Questions	Total relevant articles from literature search	Strength of evidence
Index Patients		
1. In **adult patients** (14 years and older) with {suspected renal colic with no previous history of stone/suspected renal colic with known history of renal calculus disease} what is the most appropriate and effective imaging modality for diagnosis and management of ureteral calculus disease?	145	High (level A)
2. In **pediatric patients** (younger than 14 years) with {suspected renal colic with no previous history of stone/suspected renal colic with known history of renal calculus disease} what is the most appropriate and effective imaging modality for diagnosis and management of ureteral calculus disease?	15	Low (level C)
3. In **pregnant patients** with {suspected renal colic with no previous history of stone/flank pain with known history of renal calculus disease} what is the most appropriate and effective imaging modality for diagnosis and management of ureteral calculus disease?	12	Low (level C)
4. In **adult patients** (14 years and older), what is the most appropriate and effective imaging modality for {follow up of a known ureteral stone/follow up after treatment of ureteral stones}?	28	Low (level C)

5. In **pediatric patients** (younger than 14 years), what is the most appropriate and effective imaging modality for {follow up of a known ureteral stone/follow up after treatment of ureteral stones}?	4	Low (level C)
6. In **pregnant patients**, what is the most appropriate and effective imaging modality for {follow up of a known ureteral stone/follow up after treatment of ureteral stones}?	0	N/A
Modalities		
7. What is the diagnostic accuracy (sensitivity/specificity) of **non-contrast CT** in identifying ureteral calculi?	37	High (level A)
8. What is the diagnostic accuracy (sensitivity/specificity) of **conventional radiography** (low KV, MA films) relative to non-contrast CT in identifying ureteral calculi?	21	Low (level C)
9. What is the diagnostic accuracy (sensitivity/specificity) of **ultrasound** relative to non-contrast CT in identifying ureteral calculi?	21	Low (level C)
10. What is the diagnostic accuracy (sensitivity/specificity) of **intravenous pyelography (IVP)** relative to non-contrast CT in identifying ureteral calculi?	19	Low (level C)
11. What is the diagnostic accuracy (sensitivity/specificity) of **magnetic resonance imaging (MRI)** relative to non-contrast CT in identifying ureteral calculi?	3	Low (level C)
12. What is the accuracy of nuclear medicine studies for identification of ureteral obstruction or renal damage?	6	Moderate (level B)
Conditions		

13. Of what value are **location** and **duration** of pain in predicting imaging findings for {non-contrast CT/conventional radiography/ultrasound/IVP/MRI/nuclear imaging}?	3	Low (level C)
14. What is the diagnostic significance of **hydronephrosis** for {non-contrast CT/conventional radiography/ultrasound/IVP/MRI/nuclear imaging}?	56	Moderate (level B)
15. What is the significance of **extravasation** in predicting clinical outcome?	0	N/A
16. What is the significance of secondary signs on CT (e.g. perinephric or renal stranding, renal edema, enlargement, density) in predicting clinical outcome?	25	Moderate (level B)
17. To what extent and for how long can ureteral obstruction be tolerated in an {adult/pediatric/pregnant} patient without risk of permanent renal damage/loss of function?	1	Low (level C)
18. What is the diagnostic accuracy (sensitivity/specificity) of {non-contrast CT/conventional radiography/ultrasound/IVP/MRI} based on stone location?	14	Moderate (level B)
19. What is the reliability of **hydronephrosis** as indicator of degree of obstruction and potential for loss of renal function? (If hydronephrosis is confirmed and calculous is suspected, what is the best way to assess obstruction/potential loss of renal function? (Resistive indices, IVP, etc.))	24	Moderate (level B)
20. Does the **lack of hydronephrosis** properly exclude clinically important obstruction after ureteroscopy or *extracorporeal shock wave lithotripsy* (*SWL*)?	2	Low (level C)
Consequences		
21. What **harms** are associated with utilization of non-contrast CT imaging for ureteral calculus disease?	26	Low (level C)

22. What **radiation-based risks or harms** are associated with utilization of nuclear medicine imaging for ureteral calculus disease?	2	Low (level C)
23. What are additional **risks or harms** associated with utilization of non-contrast CT imaging for ureteral calculus disease?	26	Low (level C)
24. What are additional **risks or harms** associated with utilization of conventional radiography imaging for ureteral calculus disease?	2	Low (level C)
25. What are additional **risks or harms** associated with utilization of intravenous pyelography for ureteral calculus disease?	11	Low (level C)
26. What are additional **risks or harms** associated with utilization of ultrasound imaging for ureteral calculus disease?	1	Low (level C)
27. What are additional **risks or harms** associated with utilization of magnetic resonance imaging for ureteral calculus disease?	0	N/A
28. What are additional **risks or harms** associated with utilization of nuclear medicine imaging for ureteral calculus disease?	2	Low (level C)
29. What are the economic consequences of {non-contrast CT/conventional radiography/ultrasound/ IVP/MRI/nuclear medicine/some combination of the prior}?	6	Low (level C)
Epidemiology		
30. What is the current **utilization** of {non-contrast CT/conventional radiography/ultrasound/ IVP/MRI/nuclear medicine/some combination of the prior} in management of the initial episode of ureteral colic?	8	High (level A)

31. After diagnosis of ureteral calculus disease, what is the **frequency of follow up imaging** utilizing {non-contrast CT/conventional radiography/ultrasound/ IVP/MRI/nuclear medicine/some combination of the prior}?	27	Moderate (level B)

Appendix C. Literature Search Strategies

Electronic Database Searches

The Embase and Medline databases were searched multiple times for literature related to imaging or ureteral calculi and the following topics: unenhanced (non-contrast) computed tomography (CT), conventional radiography (X-ray), ultrasound (US), intravenous pyelography (IVP), magnetic resonance imaging (MRI), nuclear medicine studies, hydronephrosis, extravasation, and follow up imaging. Searches included articles published between January 1990 and July 2011. Below are the information retrieval parameters selected for each search by the ERCI Institute.

Supplementary Table 2. Parameters for literature searches of subtopics.

Unenhanced (non-contrast) computed tomography			
Set Number	**Concept**	**Search statement**	**# identified**
1	Ureteral calculi	Ureteral calculi/ or ureter stone/ or (ureter$ adj2 (calcul$ or stone$)) or ureterolithiasis/ or ureterolithiasis or urolithiasis	24346
2		Renal colic/ or kidney colic/ or ((renal or kidney or ureter$) adj2 colic)	3698
3	Combine sets	(1 or 2) and limit 1990:current, English language, human population	12454
4	CT	3 and (tomography x-ray computed/ or exp computer assisted tomography/ or CT or (CAT adj scan$) or (computer$ adj2 tomograph$))	1868
5	Eliminate overlap	Remove duplicates from 4	1348
6	Limit by publication type	5 not (letter/ or editorial/ or news/ or comment/ or case report.mp. Or case reports/ or note/ or conference paper/ or conference abstract/ or (letter or editorial or news or comment or case reports).pt.)	810
7		5 and case series	4
8	Combine sets	6 or 7	811
Conventional radiography			
Set Number	**Concept**	**Search statement**	**# identified**
1	Ureteral calculi	Ureteral calculi/ or ureter stone/ or (ureter$ adj2 (calcul$ or stone$)) or ureterolithiasis/ or ureterolithiasis or urolithiasis	24346

2		Renal colic/ or kidney colic/ or ((renal or kidney or ureter$) adj2 colic)	3698
3	Combine sets	(1 or 2) and limit 1990:current, English language, human population	12454
4	CT	3 and (ra.fs. or exp radiography/ or x-ray or x ray or xray or radiogram$ or radiograph$ or roentgenogra$)	2831
5	Eliminate overlap	Remove duplicates from 4	2138
6	Limit by publication type	5 not (letter/ or editorial/ or news/ or comment/ or case report.mp. or case reports/ or note/ or conference abstract/ or (letter or editorial or news or comment or case reports).pt.)	1473
7		5 and case series	6
8	Combine sets	6 or 7	1475
9	Limit by importance	8 and exp *radiography/	374
10		8 and (x-ray or x ray or xray or radiogram$ or radiograph$ or roentgenogra$).ti.	80
11	Combine sets	9 or 10	417

Ultrasound

Set Number	Concept	Search statement	# identified
1	Ureteral calculi	Ureteral calculi/ or ureter stone/ or (ureter$ adj2 (calcul$ or stone$)) or ureterolithiasis/ or ureterolithiasis or urolithiasis	24334
2		Renal colic/ or kidney colic/ or ((renal or kidney or ureter$) adj2 colic)	3693
3	Combine sets	(1 or 2) and limit 1990:current, English language, human population	12438
4	Ultrasound	3 and (us.fs. or exp ultrasonography/ or exp echography/ or ultraso$ or Doppler or sonic or KUB)	2092
5	Eliminate overlap	Remove duplicates from 4	1496
6	Limit by publication type	4 not (letter/ or editorial/ or news/ or comment/ or case report.mp. or case reports/ or note/ or conference paper/ or (letter or editorial or news or comment or case reports).pt.)	1039
7		4 and case series	3
8	Combine sets	6 or 7	1040

Intravenous pyelography

Set Number	Concept	Search statement	# identified
1	Ureteral calculi	Ureteral calculi/ or ureter stone/ or (ureter$ adj2 (calcul$ or stone$)) or ureterolithiasis/ or ureterolithiasis or urolithiasis	31798
2		Renal colic/ or kidney colic/ or ((renal or kidney or ureter$) adj2 colic)	4198
3	Combine sets	(1 or 2) and limit 1990:current, English language, human population	12441
4	Intravenous pyelography	Urography/ or intravenous pyelography/ or pyelography/ or IVP or excretory radiography or excretory urography or intravenous urogram$ or IVU	41701
5	Combine sets	3 and 4	1003
6	Eliminate overlap	Remove duplicates from 4	763
7	Limit by publication type	4 not (letter/ or editorial/ or news/ or comment/ or case report.mp. or case reports/ or note/ or conference paper/ or (letter or editorial or news or comment or case reports).pt.)	546
8		4 and case series	0
9	Combine sets	7 or 8	546
10	Further refine topic	9 and (intravenous or IVP or IVU or (IV adj2 (urogram$ or pyelograph$)))	319

Magnetic resonance imaging

Set Number	Concept	Search statement	# identified
1	Ureteral calculi	Ureteral calculi/ or ureter stone/ or (ureter$ adj2 (calcul$ or stone$)) or ureterolithiasis/ or ureterolithiasis or urolithiasis	24294
2		Renal colic/ or kidney colic/ or ((renal or kidney or ureter$) adj2 colic)	3687
3	Combine sets	(1 or 2) and limit 1990:current, English language, human population	12441
4	MRI	3 and (Magnetic resonance imaging/ or exp nuclear magnetic resonance imaging/ or MR or MRI or magnetic resonance)	339
5	Eliminate overlap	Remove duplicates from 4	260

6	Limit by publication type	5 not (letter/ or editorial/ or news/ or comment/ or case report.mp. or case reports/ or note/ or conference paper/ or (letter or editorial or news or comment or case reports).pt.)	181
7		5 and case series	0
8	Combine sets	7 or 8	181

Nuclear medicine studies

Set Number	Concept	Search statement	# identified
1	Ureteral calculi	Ureteral calculi/ or ureter stone/ or (ureter$ adj2 (calcul$ or stone$)) or ureterolithiasis/ or ureterolithiasis or urolithiasis	24608
2		Renal colic/ or kidney colic/ or ((renal or kidney or ureter$) adj2 colic)	3706
3	Combine sets	(1 or 2) and limit 1990:current, English language, human population	12526
4	Nuclear medicine	3 and (exp molecular imaging/ or Nuclear medicine/ or radioisotopes/ or exp radionuclide imaging/ or ri.fs. or exp scintiscanning/ or exp emission tomography/ or gamma camera or scinti$ or SPECT or single-photon emission computed tomography or emission tomography)	250
5		3 and (PET adj2 (imag$ or scan$))	0
6		3 and ((nuclear or nucleotide or radionuclide or molecular) adj2 imag$)	9
7	Combine sets	4 or 5 or 6	250
8	Eliminate overlap	Remove duplicates from 4	201
	Limit by publication type	5 not (letter/ or editorial/ or news/ or comment/ or case report.mp. or case reports/ or note/ or conference abstract/ or conference paper/ or (letter or editorial or news or comment or case reports).pt.)	120
9		5 and case series	0
10	Combine sets	6 or 7	120

Hydronephrosis

Set Number	Concept	Search statement	# identified

1	Ureteral calculi	Ureteral calculi/ or ureter stone/ or (ureter$ adj2 (calcul$ or stone$)) or ureterolithiasis/ or ureterolithiasis or urolithiasis	31794
2		Renal colic/ or kidney colic/ or ((renal or kidney or ureter$) adj2 colic)	4198
3	Combine sets	(1 or 2) and limit 1990:current, English language, human population	12441
4	Hydronephrosis	exp hydronephrosis/ or hydronephrosis/ or hydronephrosis or dilated kidney	26439
5	Combine sets	3 and 4	862
6	Eliminate overlap	Remove duplicates from 5	631
7	Limit by publication type	6 not (letter/ or editorial/ or news/ or comment/ or case report.mp. or case reports/ or note/ or conference paper/ or (letter or editorial or news or comment or case reports).pt.)	373
8		6 and case series	3
9	Combine sets	7 or 8	374
10	Hydronephrosis as a main concept	9 and (Hydronephrosis.ti. or *hydronephrosis/)	58
11	Clinical utility of hydronephrosis	9 and ((clinical adj (validity or utility)) or (treatment adj2 (response or respond$ or monitor$)) or exp prognosis/ or exp treatment outcome/ or exp disease progression/ or exp disease course/ or treatment response/ or time factors/ or outcome assessment health care/ or outcome assessment/ or follow-up studies/ or prognosis/ or prognos$.tw.)	127
12	Combine sets	10 or 11	165

Extravasation

Set Number	Concept	Search statement	# identified
1	Ureteral calculi	Ureteral calculi/ or ureter stone/ or (ureter$ adj2 (calcul$ or stone$)) or ureterolithiasis/ or ureterolithiasis or urolithiasis	31794
2		Renal colic/ or kidney colic/ or ((renal or kidney or ureter$) adj2 colic)	4198
3	Combine sets	(1 or 2) and limit 1990:current, English language, human population	12441
4	Extravasation	Extravasation or urine extravasation/	25419
5	Combine sets	3 and 4	115

6	Eliminate overlap	Remove duplicates from 5	79
7	Limit by publication type	6 not (letter/ or editorial/ or news/ or comment/ or case report.mp. or case reports/ or note/ or conference paper/ or (letter or editorial or news or comment or case reports).pt.)	45
8		6 and case series	1
9	Combine sets	7 or 8	46

Follow-up

Set Number	Concept	Search statement	# identified
1	Ureteral calculi	Ureteral calculi/ or ureter stone/ or (ureter$ adj2 (calcul$ or stone$)) or ureterolithiasis/ or ureterolithiasis or urolithiasis	24644
2		Renal colic/ or kidney colic/ or ((renal or kidney or ureter$) adj2 colic)	3713
3	Combine sets	(1 or 2) and limit English language, human population	14993
4	MRI	3 and (Magnetic resonance imaging/ or exp nuclear magnetic resonance imaging/ or MR or MRI or magnetic resonance)	348
5	IVP	3 and (Intravenous pyelography/ or pyelography/ or (intravenous or IVP or IVU or IV adj2 (urogram$ or pyelograph$)))	818
6	Plain radiography	3 and (ra.fs. or exp radiography/ or x-ray or x ray or xray or radiogram$ or radiograph$ or roentgenogra$)	3434
7	Nuclear medicine	3 and (exp molecular imaging/ or Nuclear medicine/ or radioisotopes/ or exp radionuclide imaging/ or ri.fs. or exp scintiscanning/ or exp emission tomography/ or gamma camera or scinti$ or SPECT or single-photon emission computed tomography or emission tomography)	285
8	CT	3 and (tomography x-ray computed/ or exp computer assisted tomography/ or CT or (CAT adj scan$) or (computer$ adj2 tomograph$))	1920
9	Imaging keywords	3 and (Diagnostic imaging/ or imag$.ti.)	509
10	Combine sets	or/4-9	4392
11	Eliminate overlap	Remove duplicates from 10	3330

12	Limit by date	1990 - current	2744

Appendix D. Included/Excluded Study Tables

Supplementary Table 3. List of studies assessed in the full-text literature review.

Article UID	Authors	Title	Year	Journal	Exclude / Include	Reason for rejection	Study design
001	Aslaksen A;Gothlin JH;	Ultrasonic diagnosis of ureteral calculi in patients with acute flank pain	1990	European Journal of Radiology	**I**		DAT
002	Brown RK;Bahn DK;Walters BL;Karazim JJ;Reidinger AA;Shei KY;Morgan AW;Hurd DB;Gontina H;Kling GA;	Nuclear scintigraphy in the evaluation of renal colic	1990	Clinical Nuclear Medicine	**I**		DAT
003	Schmidt A;Rassweiler J;Gumpinger R;Mayer R;Eisenberger F;	Minimally invasive treatment of ureteric calculi using modern techniques	1990	British Journal of Urology	**E**	NR	case series
004	Spencer J;Lindsell D;Mastorakou I;	Ultrasonography compared with intravenous urography in the investigation of adults with haematuria	1990	BMJ (Clinical research ed)	**E**	Not IP	DAT
005	Svedstrom E;Alanen A;Nurmi M;	Radiologic diagnosis of renal colic: the role of plain films, excretory urography and sonography	1990	European Journal of Radiology	**I**		DAT
006	al-Hassan HK;Sabha MN;Taleb HH;Leven HO;	Value of ultrasound in persistent flank pain	1991	International surgery	**I**		DAT

007	Burge HJ;Middleton WD;McClennan BL;Hildebolt CF;	Ureteral jets in healthy subjects and in patients with unilateral ureteral calculi: comparison with color Doppler US	1991	Radiology	**I**		case-control
008	Juul N;Brons J;Torp-Pedersen S;Fredfeldt KE;	Ultrasound versus intravenous urography in the initial evaluation of patients with suspected obstructing urinary calculi	1991	Scandinavian journal of urology and nephrology Supplementum	**E**	Other: no article	
009	Kelleher JP;Plail RO;Dave SM;Cunningham DA;Snell ME;Witherow RO;	Sequential renography in acute urinary tract obstruction due to stone disease	1991	British journal of urology	**I**		case series
010	Mutgi A;Williams JW;Nettleman M;	Renal colic. Utility of the plain abdominal roentgenogram	1991	Archives of internal medicine	**I**		case series
011	Stoller ML;Floth A;Hricak H;Andersen M;Baskin LS;	Magnetic resonance imaging of renal calculi: an in vitro study	1991	The Journal of lithotripsy & stone disease	**E**	Not IP	
012	al Rasheed SA;al Mugeiren MM;al-Faquih SR;Hussein I;Muzrakchi A;	Ultrasound detection rate of childhood urolithiasis	1992	Annals of tropical paediatrics	**I**		case series
013	bdel-Wahab MF;Ramzy I;Esmat G;el Kafass H;Strickland GT;	Ultrasound for detecting Schistosoma haematobium urinary tract complications: comparison with radiographic procedures	1992	The Journal of urology	**E**	PTS CONF	
014	Embon OM;Groshar D;Shapira C;Koritny ES;Lidgi S;Mijiritsky J;Prober A;	Renal scintigraphy in initial evaluation of renal colic	1992	Urology	**I**		case series

015	Haddad MC;Sharif HS;Shahed MS;Mutaiery MA;Samihan AM;Sammak BM;Southcombe LA;Crawford AD;	Renal colic: diagnosis and outcome	1992	Radiology	**I**		DAT
016	Koga S;Arakaki Y;Matsuoka M;Ohyama C;	Spontaneous peripelvic extravasation of urine	1992	International urology and nephrology	**I**		case series
017	Nimkin K;Lebowitz RL;Share JC;Teele RL;	Urolithiasis in a children's hospital: 1985-1990	1992	Urologic Radiology	**I**		retrospective case series
018	Rodgers PM;Bates JA;Irving HC;	Intrarenal Doppler ultrasound studies in normal and acutely obstructed kidneys	1992	The British journal of radiology	**I**		case-control
019	Srivastava A;Ahlawat R;Kumar A;Kapoor R;Bhandari M;	Management of impacted upper ureteric calculi: results of lithotripsy and percutaneous litholapaxy	1992	British Journal of Urology	**I**		case series
020	Chang SC;Kuo HC;Hsu T;	Extracorporeal shock wave lithotripsy for obstructed proximal ureteral stones. A prospective randomized study comparing in situ, stent bypass and below stone catheter with irrigation strategies	1993	European Urology	**E**	NR	CCT
021	Chen J;Pu Y;Liu S;Chiu T;	Renal hemodynamics in patients with obstructive uropathy evaluated by duplex doppler sonography	1993	Journal of Urology	**I**		case-control
022	Dalla PL;Stacul F;Bazzocchi M;Pagnan L;Festini G;Marega D;	Ultrasonography and plain film versus intravenous urography in ureteric colic	1993	Clinical Radiology	**I**		case series

023	Elton TJ;Roth CS;Berquist TH;Silverstein MD;	A clinical prediction rule for the diagnosis of ureteral calculi in emergency departments	1993	Journal of general internal medicine	**I**		retrospective study
024	la Palma L;Stacul F;Bazzocchi M;Pagnan L;Festini G;Marega D;	Ultrasonography and plain film versus intravenous urography in ureteric colic	1993	Clinical Radiology	**E**	Other: replicated	
025	Platt JF;Rubin JM;Ellis JH;	Acute renal obstruction: evaluation with intrarenal duplex Doppler and conventional US	1993	Radiology	**I**		case series
026	Wang YH;Grenabo L;Hedelin H;Pettersson S;Wikholm G;Zachrisson BF;	Analysis of stone fragility in vitro and in vivo with piezoelectric shock waves using the EDAP LT-01	1993	Journal of Urology	**E**	NR	case series
027	Chuah S;Changchien C;Tai D;Chiou S;Lee C;Kuo - C.H.;Chen J;Chiu K;	Hydronephrosis accidentally detected by gastrointestinal sonography	1994	Journal of Clinical Ultrasound	**E**	PTS CONF	
028	Collie DA;Paul AB;Wild SR;	The diagnostic yield of intravenous urography: a demographic study	1994	British Journal of Urology	**E**	PTS CONF	
029	Farsi HM;Mosli HA;Alzimaity M;Bahnassay AA;Ibrahim MA;	In situ extracorporeal shock wave lithotripsy for primary ureteric calculi	1994	Urology	**I**		retrospective case series
030	Kumar A;Kumar RV;Mishra VK;Ahlawat R;Kapoor R;Bhandari M;	Should upper ureteral calculi be manipulated before extracorporeal shock wave lithotripsy? A prospective controlled trial	1994	The Journal of urology	**I**		CCT

031	Mattelaer P;Schroder T;Fischer N;Jakse G;	In situ extracorporeal shockwave lithotripsy of distal ureteral stones: parameters for therapeutic success	1994	Urologia Internationalis	**I**		case series
032	Tublin ME;Dodd GD;Verdile VP;	Acute renal colic: diagnosis with duplex Doppler US	1994	Radiology	**I**		case series
033	Chen MY;Zagoria RJ;Dyer RB;	Interureteric ridge edema: incidence and etiology	1995	Abdominal Imaging	**I**		case series
034	Chia SJ;Lau W;Tan PK;Consigliere D;Li MK;Low CH;	Ureteric colic: value of initial investigations and the outcome	1995	Annals of the Academy of Medicine, Singapore	**I**		case series
035	Robert M;Delbos O;Guiter J;Grasset D;	In situ piezoelectric extracorporeal shock wave lithotripsy of ureteric stones	1995	British Journal of Urology	**I**		case series
036	Rothpearl A;Frager D;Subramanian A;Bashist B;Baer J;Kay C;Cooke K;Raia C;	MR urography: Technique and application	1995	Radiology	**E**	PTS CONF	
037	Roy C;Saussine C;Jahn C;Bras YL;Steichen G;Delepaul B;Campos M;Chambron J;Jacqmin D;	Fast imaging MR assessment of ureterohydronephrosis during pregnancy	1995	Magnetic Resonance Imaging	**I**		case series
038	Smith RC;Rosenfield AT;Choe KA;Essenmacher KR;Verga M;Glickman MG;Lange RC;	Acute flank pain: comparison of non-contrast-enhanced CT and intravenous urography	1995	Radiology	**I**		DAT

039	Sommer FG;Jeffrey RBJ;Rubin GD;Napel S;Rimmer SA;Benford J;Harter PM;	Detection of ureteral calculi in patients with suspected renal colic: value of reformatted noncontrast helical CT	1995	AJR American journal of roentgenology	I		case series
040	Wrenn K;	Emergency intravenous pyelography in the setting of possible renal colic: is it indicated?	1995	Annals of Emergency Medicine	I		DAT
041	Bon D;Dore B;Irani J;Marroncle M;Aubert J;	Radiographic prognostic criteria for extracorporeal shock-wave lithotripsy: a study of 485 patients	1996	Urology	I		DAT
042	Boyd R;Gray AJ;	Role of the plain radiograph and urinalysis in acute ureteric colic	1996	Journal of accident & emergency medicine	I		DAT
043	de Toledo LS;Martinez-Berganza Asensio T;Cozcolluela Cabrejas R;de Gregorio Ariza MA;Pardina Cortina P;Ripa Saldias L;	Doppler-duplex ultrasound in renal colic	1996	European Journal of Radiology	I		DAT
044	Gorelik U;Ulish Y;Yagil Y;	The use of standard imaging techniques and their diagnostic value in the workup of renal colic in the setting of intractable flank pain	1996	Urology	I		retrospective case series
045	Katz DS;Lane MJ;Sommer FG;	Unenhanced helical CT of ureteral stones: incidence of associated urinary tract findings	1996	AJR American journal of roentgenology	I		retrospective review

046	Kundu AK;Bhattacherjee GC;Saha BB;	Ultrasonography in acute flank pain	1996	Journal of the Indian Medical Association	**I**		DAT
047	Lee HJ;Kim SH;Jeong YK;Yeun KM;	Doppler sonographic resistive index in obstructed kidneys	1996	Journal of Ultrasound in Medicine	**E**	PTS CONF	
048	Mutazindwa T;Husseini T;	Imaging in acute renal colic: the intravenous urogram remains the gold standard	1996	European Journal of Radiology	**I**		DAT
049	Regan F;Bohlman ME;Khazan R;Rodriguez R;Schultze-Haakh H;	MR urography using HASTE imaging in the assessment of ureteric obstruction	1996	AJR American journal of roentgenology	**I**		prospective study
050	Roy C;Saussine C;LeBras Y;Delepaul B;Jahn C;Steichen G;Jacqmin D;Chambron J;	Assessment of painful ureterohydronephrosis during pregnancy by MR urography	1996	European Radiology	**I**		DAT
051	Seitz K;Bloching H;Reuss J;Pfeilsticker U;Valchera A;Rettenmaier G;	Sonographical diagnosis of suspected ureteric calculi	1996	European Journal of Ultrasound	**I**		prospective study
052	Shokeir AA;Provoost AP;El-Azab M;Dawaba M;Nijman RJM;	Renal Doppler ultrasound in children with obstructive uropathy: Effect of intravenous normal saline fluid load and furosemide	1996	Journal of Urology	**E**	No data	
053	Smith RC;Verga M;Dalrymple N;McCarthy S;Rosenfield AT;	Acute ureteral obstruction: value of secondary signs of helical unenhanced CT	1996	AJR American journal of roentgenology	**I**		case series
054	Smith RC;Verga M;McCarthy S;Rosenfield AT;	Diagnosis of acute flank pain: value of unenhanced helical CT	1996	AJR American journal of roentgenology	**I**		DAT

055	Tang Y;Yamashita Y;Namimoto T;Abe Y;Nishiharu T;Sumi S;Takahashi M;	The value of MR urography that uses HASTE sequences to reveal urinary tract disorders	1996	American Journal of Roentgenology	**E**	Not IP	
056	Zwergel T;Lindenmeir T;Wullich B;	Management of acute hydronephrosis in pregnancy by ureteral stenting	1996	European Urology	**I**		case series
057	Andresen R;Wegner HE;	Intravenous urography revisited in the age of ultrasound and computerized tomography: diagnostic yield in cases of renal colic, suspected pelvic and abdominal malignancies, suspected renal mass, and acute pyelonephritis	1997	Urologia Internationalis	**E**	NR	retrospective case series
058	Chen MY;Zagoria RJ;Dyer RB;	Radiologic findings in acute urinary tract obstruction	1997	The Journal of emergency medicine	**E**	NR	
059	Dobbins JM;Novelline RA;Rhea JT;Rao PM;Prien EL;Dretler SR;	Helical computed tomography of urinary tract stones: Accuracy and diagnostic value of stone size and density measurements	1997	Emergency Radiology	**E**	Not IP	
060	Fielding JR;Fox LA;Heller H;Seltzer SE;Tempany CM;Silverman SG;Steele G;	Spiral CT in the evaluation of flank pain: overall accuracy and feature analysis	1997	Journal of computer assisted tomography	**I**		case series
061	Fielding JR;Steele G;Fox LA;Heller H;Loughlin KR;	Spiral computerized tomography in the evaluation of acute flank pain: a replacement for excretory urography	1997	The Journal of urology	**I**		DAT

062	Gottlieb RH;Weinberg EP;Rubens DJ;Monk RD;Grossman EB;	Renal sonography: Can it be used more selectively in the setting of an elevated serum creatinine level?	1997	American Journal of Kidney Diseases	**E**	No data	
063	Heneghan JP;Dalrymple NC;Verga M;Rosenfield AT;Smith RC;	Soft-tissue 'rim' sign in the diagnosis of ureteral calculi with use of unenhanced helical CT	1997	Radiology	**I**		retrospective review
064	Huang Y;Zhu Z;	Massive hydronephrosis associated with traumatic rupture	1997	Injury	**E**	Not IP	
065	Hussain S;O'Malley M;Jara H;Sadeghi-Nejad H;Yucel EK;	MR urography	1997	Magnetic resonance imaging clinics of North America	**E**	No data	
066	Kawashima A;Sandler CM;Boridy IC;Takahashi N;Benson GS;Goldman SM;	Unenhanced helical CT of ureterolithiasis: value of the tissue rim sign	1997	AJR American journal of roentgenology	**I**		DAT
067	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	1997	Radiology	**I**		retrospective study
068	Liberman SN;Halpern EJ;Sullivan K;Bagley DH;	Spiral computed tomography for staghorn calculi	1997	Urology	**E**	Not IP	DAT
069	Lindell A;	Studies on renal function in patients with cystinuria	1997	Nephron	**E**	Not IP	case series

070	Tasso SR;Shields CP;Rosenberg CR;Sixsmith DM;Pang DS;	Effectiveness of selective use of intravenous pyelography in patients presenting to the emergency department with ureteral colic	1997	Academic emergency medicine : official journal of the Society for Academic Emergency Medicine	**I**		Randomized prospective study
071	al Busaidy SS;Prem AR;Medhat M;Giriraj D;Gopakumar P;Bhat HS;	Paediatric ureteric calculi: efficacy of primary in situ extracorporeal shock wave lithotripsy	1998	British Journal of Urology	**I**		case series
072	Bell TV;Fenlon HM;Davison BD;Ahari HK;Hussain S;	Unenhanced helical CT criteria to differentiate distal ureteral calculi from pelvic phleboliths	1998	Radiology	**I**		retrospective analysis
073	Chang S;	Diuresis renosonography for the assessment of obstructive uropathy: Clinical applications and limitations	1998	Journal of Medical Ultrasound	**E**	No data	
074	Dalrymple NC;Verga M;Anderson KR;Bove P;Covey AM;Rosenfield AT;Smith RC;	The value of unenhanced helical computerized tomography in the management of acute flank pain	1998	The Journal of urology	**I**		retrospective review
075	Fielding JR;Silverman SG;Samuel S;Zou KH;Loughlin KR;	Unenhanced helical CT of ureteral stones: a replacement for excretory urography in planning treatment	1998	AJR American journal of roentgenology	**I**		retrospective review

076	Freed KS;Paulson EK;Frederick MG;Preminger GM;Shusterman DJ;Keogan MT;Vieweg J;Smith RH;Nelson RC;Delong DM;Leder RA;	Interobserver variability in the interpretation of unenhanced helical CT for the diagnosis of ureteral stone disease	1998	Journal of Computer Assisted Tomography	I		retrospective review
077	Ghali AM;Elmalik EM;Ibrahim AI;Abdulhameed E;el Tahir MI;	Cost-effective emergency diagnosis plan for urinary stone patients presenting with ureteric colic	1998	European Urology	I		prospective study
078	Henderson SO;Hoffner RJ;Aragona JL;Groth DE;Esekogwu VI;Chan D;	Bedside emergency department ultrasonography plus radiography of the kidneys, ureters, and bladder vs intravenous pyelography in the evaluation of suspected ureteral colic	1998	Academic emergency medicine : official journal of the Society for Academic Emergency Medicine	I		prospective study
079	Miller OF;Rineer SK;Reichard SR;Buckley RG;Donovan MS;Graham IR;Goff WB;Kane CJ;	Prospective comparison of unenhanced spiral computed tomography and intravenous urogram in the evaluation of acute flank pain	1998	Urology	I		DAT
080	Opdenakker L;Oyen R;Vervloessem I;Goethuys H;Baert AL;Baert LV;Marchal G;	Acute obstruction of the renal collecting system: the intrarenal resistive index is a useful yet time-dependent parameter for diagnosis	1998	European Radiology	I		DAT
081	Parulkar BG;Hopkins TB;Wollin MR;Howard PJJ;Lal A;	Renal colic during pregnancy: a case for conservative treatment	1998	The Journal of urology	I		DAT

082	Rosen CL;Brown DF;Sagarin MJ;Chang Y;McCabe CJ;Wolfe RE;	Ultrasonography by emergency physicians in patients with suspected ureteral colic	1998	The Journal of emergency medicine	**E**	NR	DAT
083	Roy C;Tuchmann C;Pfleger D;Guth S;Saussine C;Jacqmin D;	Potential role of duplex Doppler sonography in acute renal colic	1998	Journal of clinical ultrasound : JCU	**I**		retrospective study
084	Takahashi N;Kawashima A;Ernst RD;Boridy IC;Goldman SM;Benson GS;Sandler CM;	Ureterolithiasis: can clinical outcome be predicted with unenhanced helical CT?	1998	Radiology	**I**		retrospective review
085	Vieweg J;Teh C;Freed K;Leder RA;Smith RH;Nelson RH;Preminger GM;	Unenhanced helical computerized tomography for the evaluation of patients with acute flank pain	1998	The Journal of urology	**I**		DAT
086	Yilmaz S;Sindel T;Arslan G;Ozkaynak C;Karaali K;Kabaalioglu A;Luleci E;	Renal colic: comparison of spiral CT, US and IVU in the detection of ureteral calculi	1998	European Radiology	**I**		DAT
087	Zou KH;Tempany CM;Fielding JR;Silverman SG;	Original smooth receiver operating characteristic curve estimation from continuous data: statistical methods for analyzing the predictive value of spiral CT of ureteral stones	1998	Academic radiology	**E**	No data	
088	Aytac SK;Ozcan H;	Effect of color Doppler system on the twinkling sign associated with urinary tract calculi	1999	Journal of Clinical Ultrasound	**I**		DAT

089	Boridy IC;Kawashima A;Goldman SM;Sandler CM;	Acute ureterolithiasis: nonenhanced helical CT findings of perinephric edema for prediction of degree of ureteral obstruction	1999	Radiology	**I**		retrospective case series
090	Boridy IC;Nikolaidis P;Kawashima A;Goldman SM;Sandler CM;	Ureterolithiasis: value of the tail sign in differentiating phleboliths from ureteral calculi at nonenhanced helical CT	1999	Radiology	**I**		retrospective review
091	Boulay I;Holtz P;Foley WD;White B;Begun FP;	Ureteral calculi: diagnostic efficacy of helical CT and implications for treatment of patients	1999	AJR American journal of roentgenology	**I**		retrospective analysis
092	Catalano C;Pavone P;Laghi A;Scipioni A;Panebianco V;Brillo R;Fraioli F;Passariello R;	MR pyelography and conventional MR imaging in urinary tract obstruction	1999	Acta radiologica (Stockholm, Sweden : 1987)	**I**		case series
093	Denton ER;MacKenzie A;Greenwell T;Popert R;Rankin SC;	Unenhanced helical CT for renal colic--is the radiation dose justifiable?	1999	Clinical Radiology	**I**		case series
094	Dorio PJ;Pozniak MA;Lee FTJ;Kuhlman JE;	Non-contrast-enhanced helical computed tomography for the evaluation of patients with acute flank pain	1999	WMJ : official publication of the State Medical Society of Wisconsin	**I**		retrospective review
095	Hayashi M;Yasumoto H;Kasaoka Y;Inoue K;Shigeta M;Tazuma S;	Risk factors for recurrence or regrowth of upper urinary tract calculi following extracorporeal shock wave lithotripsy	1999	Nishinihon Journal of Urology	**E**	Other: no article	
096	Kazerooni NL;Dunnick NR;	Current diagnosis and treatment of urolithiasis	1999	Radiologist	**E**	No data	

097	Levine J;Neitlich J;Smith RC;	The value of prone scanning to distinguish ureterovesical junction stones from ureteral stones that have passed into the bladder: leave no stone unturned	1999	AJR American journal of roentgenology	I		retrospective study
098	Niall O;Russell J;MacGregor R;Duncan H;Mullins J;	A comparison of noncontrast computerized tomography with excretory urography in the assessment of acute flank pain	1999	The Journal of urology	I		DAT
099	Richards JR;Christman CA;	Intravenous urography in the emergency department: when do we need it?	1999	European journal of emergency medicine : official journal of the European Society for Emergency Medicine	I		retrospective study
100	Schwartz BF;Schenkman N;Armenakas NA;Stoller ML;	Imaging characteristics of indinavir calculi	1999	The Journal of urology	I		retrospective case series
101	Shigeta M;Kasaoka Y;Yasumoto H;Inoue K;Usui T;Hayashi M;Tazuma S;	Fate of residual fragments after successful extracorporeal shock wave lithotripsy	1999	International journal of urology : official journal of the Japanese Urological Association	I		case series
102	Shokeir AA;Abdulmaaboud M;	Resistive index in renal colic: a prospective study	1999	BJU International	I		prospective study

103	Shokeir AA;Abdulmaaboud M;Farage Y;Mutabagani H;	Resistive index in renal colic: The effect of nonsteroidal antiinflammatory drugs	1999	BJU International	**I**		case series
104	Sourtzis S;Thibeau JF;Damry N;Raslan A;Vandendris M;Bellemans M;	Radiologic investigation of renal colic: unenhanced helical CT compared with excretory urography	1999	AJR American journal of roentgenology	**I**		DAT
105	Traubici J;Neitlich JD;Smith RC;	Distinguishing pelvic phleboliths from distal ureteral stones on routine unenhanced helical CT: is there a radiolucent center?	1999	AJR American journal of roentgenology	**E**	NR	
106	Zisch R;Kerbl K;	Magnetic resonance urography in the evaluation of acute flank pain	1999	Techniques in Urology	**I**		case series
107	Butler EL;Cox SM;Eberts EG;Cunningham FG;	Symptomatic nephrolithiasis complicating pregnancy	2000	Obstetrics and Gynecology	**I**		retrospective case series
108	Connolly LP;Zurakowski D;Peters CA;Dicanzio J;Ephraim P;Paltiel HJ;Share JC;Treves ST;	Variability of diuresis renography interpretation due to method of post-diuretic renal pelvic clearance half-time determination	2000	Journal of Urology	**E**	PTS CONF	
109	Cummings JM;Boullier JA;Izenberg SD;Kitchens DM;Kothandapani RV;	Prediction of spontaneous ureteral calculous passage by an artificial neural network	2000	The Journal of urology	**E**	No data	
110	Diel J;Perlmutter S;Venkataramanan N;Mueller R;Lane MJ;Katz DS;	Unenhanced helical CT using increased pitch for suspected renal colic: an effective technique for radiation dose reduction?	2000	Journal of Computer Assisted Tomography	**I**		DAT

111	Erdogru T;Kaplancan T;Aras N;Aker O;Eroglu E;	Evaluation of acute flank pain with non-contrast spiral CT and its predictive role on clinical outcome	2000	Marmara Medical Journal	**I**		DAT
112	Farres MT;Gattegno B;Ronco P;Flahault A;Paula-Souza R;Bigot JM;	Nonnephrotoxic, dynamic, contrast enhanced magnetic resonance urography: Use in nephrology and urology	2000	Journal of Urology	**I**		case series
113	Grenier N;Pariente JL;Trillaud H;Soussotte C;Douws C;	Dilatation of the collecting system during pregnancy: Physiologic vs obstructive dilatation	2000	European Radiology	**E**	No data	
114	Jackman SV;Potter SR;Regan F;Jarrett TW;	Plain abdominal x-ray versus computerized tomography screening: sensitivity for stone localization after nonenhanced spiral computerized tomography	2000	The Journal of urology	**E**	No data	
115	Jung P;Brauers A;Nolte-Ernsting CA;Jakse G;Gunther RW;	Magnetic resonance urography enhanced by gadolinium and diuretics: a comparison with conventional urography in diagnosing the cause of ureteric obstruction	2000	BJU International	**I**		DAT
116	Katz DS;Scheer M;Lumerman JH;Mellinger BC;Stillman CA;Lane MJ;	Alternative or additional diagnoses on unenhanced helical computed tomography for suspected renal colic: experience with 1000 consecutive examinations	2000	Urology	**I**		retrospective review

117	Kinn AC;	Ureteropelvic junction obstruction: long-term followup of adults with and without surgical treatment	2000	The Journal of urology	**E**	PTS CONF	
118	Lee JY;Cho JY;Kim SH;	Genitourinary lesions showing twinkling artifacts on color Doppler ultrasound	2000	Journal of Medical Ultrasound	**I**		prospective study
119	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	2000	Radiology	**I**		DAT
120	Lorberboym M;Kapustin Z;Elias S;Nikolov G;Katz R;	The role of renal scintigraphy and unenhanced helical computerized tomography in patients with ureterolithiasis	2000	European journal of nuclear medicine	**I**		case series
121	Nachmann MM;Harkaway RC;Summerton SL;Horrow MM;Kirby CL;Fields RG;Ginsberg PC;	Helical CT scanning: The primary imaging modality for acute flank pain	2000	American Journal of Emergency Medicine	**I**		DAT
122	Nishimura T;Abe H;Miura T;Uchikoba T;Tsuboi N;Yamamoto H;Kobayashi K;	Post-voiding repeated renal ultrasonography for slight hydronephrosis detected during screening for asymptomatic microhematuria	2000	International journal of urology : official journal of the Japanese Urological Association	**E**	Not IP	
123	Probert JL;Mills R;Persad RA;Sethia KK;	Imaging assessment of uncomplicated bladder outflow obstruction	2000	International Journal of Clinical Practice	**I**		prospective study
124	Ronaghi AH;Cochran ST;Ronaghi N;	Advances in imaging the urinary tract with spiral CT	2000	Radiologist	**E**	No data	

125	Rosser CJ;Zagoria R;Dixon R;Scurry WC;Bare RL;McCullough DL;Assimos DG;	Is there a learning curve in diagnosing urolithiasis with noncontrast helical computed tomography?	2000	Canadian Association of Radiologists journal = Journal l'Association canadienne des radiologistes	I		DAT
126	Sfakianakis GN;Cohen DJ;Braunstein RH;Leveillee RJ;Lerner I;Bird VG;Sfakianakis E;Georgiou MF;Block NL;Lynne CM;	MAG3-F0 scintigraphy in decision making for emergency intervention in renal colic after helical CT positive for a urolith	2000	Journal of Nuclear Medicine	I		DAT
127	Sheafor DH;Hertzberg BS;Freed KS;Carroll BA;Keogan MT;Paulson EK;DeLong DM;Nelson RC;	Nonenhanced helical CT and US in the emergency evaluation of patients with renal colic: prospective comparison	2000	Radiology	I		DAT
128	Shield AC;Chu K;Brown AFT;	Urinalysis and the plain abdominal radiograph in the diagnosis of ureteric colic	2000	Emergency Medicine	I		retrospective cohort study
129	Shokeir AA;Mahran MR;Abdulmaaboud M;	Renal colic in pregnant women: role of renal resistive index	2000	Urology	I		DAT
130	Smith SL;Somers JM;Broderick N;Halliday K;	The role of the plain radiograph and renal tract ultrasound in the management of children with renal tract calculi	2000	Clinical Radiology	I		retrospective study

131	Yoon DY;Bae SH;Choi CS;	Transrectal ultrasonography of distal ureteral calculi: comparison with intravenous urography	2000	Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine	**I**		prospective study
132	Ames CD;Older RA;	Imaging in urinary tract obstruction	2001	Brazilian Journal of Urology	**E**	No data	
133	Collins MC;Rosario DJ;	Emergency uroradiology	2001	Imaging	**E**	No data	
134	Cvitkovic Kuzmic A;Brkljacic B;Rados M;Galesic K;	Doppler visualization of ureteric jets in unilateral hydronephrosis in children and adolescents	2001	European Journal of Radiology	**E**	PTS CONF	
135	Guest AR;Cohan RH;Korobkin M;Platt JF;Bundschu CC;Francis IR;Gebramarium A;Murray UM;	Assessment of the clinical utility of the rim and comet-tail signs in differentiating ureteral stones from phleboliths	2001	AJR American journal of roentgenology	**I**		DAT
136	Hamm M;Wawroschek F;Weckermann D;Knopfle E;Hackel T;Hauser H;Krawczak G;Harzmann R;	Unenhanced helical computed tomography in the evaluation of acute flank pain	2001	European Urology	**I**		DAT
137	Hammoud DA;Khoury NJ;Haddad MC;	Unenhanced spiral CT scan in the initial evaluation of renal colic: AUBMC experience	2001	Le Journal medical libanais The Lebanese medical journal	**I**		retrospective review

138	Homer JA;vies-Payne DL;Peddinti BS;	Randomized prospective comparison of non-contrast enhanced helical computed tomography and intravenous urography in the diagnosis of acute ureteric colic	2001	Australasian radiology	**I**		CCT
139	Jae YL;Seung HK;Joeng YC;Han D;	Color and power doppler twinkling artifacts from urinary stones: Clinical observations and phantom studies	2001	American Journal of Roentgenology	**I**		prospective study
140	Jeng C;Kung C;Wang Y;Wu C;Lee W;Fan J;Huang Y;	Urolithiasis in patients with acute flank pain: Comparison of plain abdominal radiography to unenhanced spiral CT	2001	Chinese Journal of Radiology	**I**		DAT
141	Kim JC;	US and CT findings of xanthogranulomatous pyelonephritis	2001	Clinical Imaging	**E**	NR	retrospective study
142	Kim JC;	Central lucency of pelvic phleboliths: comparison of radiographs and noncontrast helical CT	2001	Clinical imaging	**E**	NR	
143	Lee JY;Kim SH;Cho JY;Han D;	Color and power Doppler twinkling artifacts from urinary stones: clinical observations and phantom studies	2001	AJR American journal of roentgenology	**E**	Other: no article	
144	Longo J;Akbar SA;Schaff T;Jafri ZH;Jackson RE;	A prospective comparative study of non-contrast helical computed tomography and intravenous urogram for the assessment of renal colic	2001	Emergency Radiology	**I**		DAT

145	Lumerman J;Gershbaum MD;Hines J;Nardi P;Beuchert P;Katz DS;	Unenhanced helical computed tomography for the evaluation of suspected renal colic in the adolescent population: a pilot study	2001	Urology	I		DAT
146	Meagher T;Sukumar VP;Collingwood J;Crawley T;Schofield D;Henson J;Lakin K;Connolly D;Giles J;	Low dose computed tomography in suspected acute renal colic	2001	Clinical Radiology	I		DAT
147	Myers MT;Elder JS;Sivit CJ;Applegate KF;	Unenhanced helical CT in the evaluation of the urinary tract in children and young adults following urinary tract reconstruction: Comparison with sonography	2001	Pediatric Radiology	I		DAT
148	Patlas M;Farkas A;Fisher D;Zaghal I;Hadas-Halpern I;	Ultrasound vs CT for the detection of ureteric stones in patients with renal colic	2001	British Journal of Radiology	I		DAT
149	Shokeir AA;Abdulmaaboud M;	Prospective comparison of nonenhanced helical computerized tomography and Doppler ultrasonography for the diagnosis of renal colic	2001	The Journal of urology	I		DAT
150	Smergel E;Greenberg SB;Crisci KL;Salwen JK;	CT urograms in pediatric patients with ureteral calculi: do adult criteria work?	2001	Pediatric Radiology	I		DAT
151	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	2001	AJR American journal of roentgenology	I		prospective study

152	Surange RS;Jeygopal NS;Chowdhury SD;Sharma NK;	Bedside ultrasound: a useful tool for the on-call urologist?	2001	International Urology and Nephrology	**I**		prospective study
153	Van Beers BE;Dechambre S;Hulcelle P;Materne R;Jamart J;	Value of multislice helical CT scans and maximum-intensity-projection images to improve detection of ureteral stones at abdominal radiography	2001	AJR American journal of roentgenology	**I**		DAT
154	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	2001	AJR American journal of roentgenology	**I**		DAT
155	Wong SK;Ng LG;Tan BS;Cheng CW;Chee CT;Chan LP;Lo HG;	Acute renal colic: value of unenhanced spiral computed tomography compared with intravenous urography	2001	Annals of the Academy of Medicine, Singapore	**E**	No data	
156	Yossepowitch O;Lifshitz DA;Dekel Y;Gross M;Keidar DM;Neuman M;Livne PM;Baniel J;	Predicting the success of retrograde stenting for managing ureteral obstruction	2001	Journal of Urology	**E**	PTS CONF	
157	Zagoria RJ;Khatod EG;Chen MYM;	Abdominal radiography after CT reveals urinary calculi: A method to predict usefulness of abdominal radiography on the basis of size and CT attenuation of calculi	2001	American Journal of Roentgenology	**I**		DAT

158	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 99mtechnetium mercaptoacetyltriglycine diuretic scintirenography for patients with acute renal colic	2002	Journal of Urology	**I**		retrospective review
159	Brkljacic B;Kuzmic AC;Dmitrovic R;Rados M;Vidjak V;	Doppler sonographic renal resistance index and resistance index ratio in children and adolescents with unilateral hydronephrosis	2002	European Radiology	**I**		DAT
160	Buchholz NPN;Rhabar MH;Talati J;	Is measurement of stone surface area necessary for SWL treatment of nonstaghorn calculi?	2002	Journal of endourology / Endourological Society	**E**	NR	
161	Budau M;Chira I;Ambert V;Pascu M;Radu M;Onu M;Pop T;Persu S;Popescu M;Braticevici B;	Can we renounce performing the intravenous urography in the preoperative evaluation for ESWL treatment?	2002	Archivio italiano di urologia, andrologia : organo ufficiale [di] Societa italiana di ecografia urologica e nefrologica / Associazione ricerche in urologia	**I**		DAT

162	Catalano O;Nunziata A;Altei F;Siani A;	Suspected ureteral colic: primary helical CT versus selective helical CT after unenhanced radiography and sonography	2002	AJR American journal of roentgenology	**I**		DAT
163	Catalano O;Nunziata A;Sandomenico F;Siani A;	Acute flank pain: Comparison of unenhanced helical CT and ultrasonography in detecting causes other than ureterolithiasis	2002	Emergency Radiology	**I**		DAT
164	Cohnen M;Brause M;May P;Hetzel G;Saleh A;Grabensee B;Modder U;	Contrast-enhanced MR urography in the evaluation of renal transplants with urological complications	2002	Clinical nephrology	**I**		case series
165	Coll DM;Varanelli MJ;Smith RC;	Relationship of spontaneous passage of ureteral calculi to stone size and location as revealed by unenhanced helical CT	2002	AJR American journal of roentgenology	**E**	No data	
166	Eshed I;Kornecki A;Rabin A;Elias S;Katz R;	Unenhanced spiral CT for the assessment of renal colic. How does limiting the referral base affect the discovery of additional findings not related to urinary tract calculi?	2002	European Journal of Radiology	**E**	Other: no article	
167	Eshed I;Witzling M;	The role of unenhanced helical CT in the evaluation of suspected renal colic and atypical abdominal pain in children	2002	Pediatric Radiology	**I**		DAT
168	Geavlete P;Georgescu D;Cauni V;Ni G;	Value of duplex Doppler ultrasonography in renal colic	2002	European Urology	**E**	Other: no article	

169	Geavlete P;Georgescu D;Cauni V;Nita G;	Value of duplex Doppler ultrasonography in renal colic	2002	European Urology	I		prospective study
170	German I;Lantsberg S;Crystal P;Assali M;Rachinsky I;Kaneti J;Neulander E;	Non contrast computerized tomography and dynamic renal scintigraphy in the evaluation of patients with renal colic: are both necessary?	2002	European Urology	I		DAT
171	Gottlieb RH;La TC;Erturk EN;Sotack JL;Voci SL;Holloway RG;Syed L;Mikityansky I;Tirkes AT;Elmarzouky R;Zwemer FL;Joseph JV;Davis D;DiGrazio WJ;Messing EM;	CT in detecting urinary tract calculi: Influence on patient imaging and clinical outcomes	2002	Radiology	I		retrospective review
172	Hamm M;Knopfle E;Wartenberg S;Wawroschek F;Weckermann D;Harzmann R;	Low dose unenhanced helical computerized tomography for the evaluation of acute flank pain	2002	The Journal of urology	I		DAT
173	Irving SO;Burgess NA;	Managing severe loin pain in pregnancy	2002	BJOG : an international journal of obstetrics and gynaecology	I		prospective study
174	Kmetec A;Peskar-Babnik D;Buturovic-Ponikvar J;	Time-dependent changes of resistive index in acute renal obstruction during nonsteroidal drug administration	2002	BJU International	I		DAT

175	Kochakarn W;Ratana-Olarn K;Viseshsindh V;Muangman V;	Ureteral calculi during pregnancy: review of the management at Ramathibodi Hospital	2002	Journal of the Medical Association of Thailand = Chotmaihet thangphaet	**I**		retrospective case series
176	Lifshitz DA;Lingeman JE;	Ureteroscopy as a first-line intervention for ureteral calculi in pregnancy	2002	Journal of endourology / Endourological Society	**I**		retrospective analysis
177	Narepalem N;Sundaram CP;Boridy IC;Yan Y;Heiken JP;Clayman RV;	Comparison of helical computerized tomography and plain radiography for estimating urinary stone size	2002	The Journal of urology	**I**		DAT
178	Sharfuddin A;Kumar S;	Renal colic: Keys to diagnosis and management	2002	Consultant	**E**	No data	
179	Shokeir AA;Shoma AM;Mosbah A;Mansour O;bol-Ghar M;Eassa W;El-Asmy A;	Noncontrast computed tomography in obstructive anuria: a prospective study	2002	Urology	**I**		case-control
180	Sridhar S;Kumaravel N;Easwarakumar KS;	Segmentation of renal calculi in ultrasound images	2002	Medical Informatics and the Internet in Medicine	**E**	NR	
181	Sudah M;Vanninen RL;Partanen K;Kainulainen S;Malinen A;Heino A;Ala-Opas M;	Patients with acute flank pain: comparison of MR urography with unenhanced helical CT	2002	Radiology	**I**		DAT
182	Volkmer BG;Nesslauer T;Kuefer R;Engel O;Kraemer SC;Gottfried H;	Visualization of urinary stones by 3-D ultrasound with surface rendering	2002	Ultrasound in Medicine and Biology	**I**		DAT

183	Ahmad NA;Ather MH;Rees J;	Incidental diagnosis of diseases on un-enhanced helical computed tomography performed for ureteric colic	2003	BMC Urology	**I**		retrospective review
184	Delakas D;Karyotis I;Daskalopoulos G;Lianos E;Mavromanolakis E;	Independent predictors of failure of shockwave lithotripsy for ureteral stones employing a second-generation lithotripter	2003	Journal of Endourology	**I**		retrospective case series
185	Demirel A;Suma S;	The efficacy of non-contrast helical computed tomography in the prediction of urinary stone composition in vivo	2003	Journal of International Medical Research	**I**		DAT
186	Ege G;Akman H;Kuzucu K;Yildiz S;	Acute ureterolithiasis: incidence of secondary signs on unenhanced helical CT and influence on patient management	2003	Clinical Radiology	**I**		case series
187	Eray O;Cubuk MS;Oktay C;Yilmaz S;Cete Y;Ersoy FF;	The efficacy of urinalysis, plain films, and spiral CT in ED patients with suspected renal colic	2003	The American journal of emergency medicine	**I**		DAT
188	Etemad A;Brems-Dalgaard E;Thomsen HS;	Outcome of intravenous urography in the year 2000	2003	Abdominal Imaging	**E**	PTS CONF	
189	Greenstein A;Beri A;Sofer M;Matzkin H;	Is intravenous urography a prerequisite for renal shockwave lithotripsy?	2003	Journal of endourology / Endourological Society	**E**	NR	
190	Haroun A;	Duplex Doppler sonography in patients with acute renal colic: prospective study and literature review	2003	International Urology and Nephrology	**I**		DAT

191	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	2003	Radiology	**I**		DAT
192	Holdgate A;Chan T;	How accurate are emergency clinicians at interpreting noncontrast computed tomography for suspected renal colic?	2003	Academic emergency medicine : official journal of the Society for Academic Emergency Medicine	**I**		DAT
193	Katz D;McGahan JP;Gerscovich EO;Troxel SA;Low RK;	Correlation of ureteral stone measurements by CT and plain film radiography: utility of the KUB	2003	Journal of endourology / Endourological Society	**I**		retrospective review
194	Kobayashi T;Nishizawa K;Mitsumori K;Ogura K;	Impact of date of onset on the absence of hematuria in patients with acute renal colic	2003	The Journal of urology	**E**	NR	
195	Kobayashi T;Nishizawa K;Watanabe J;Ogura K;	Clinical characteristics of ureteral calculi detected by nonenhanced computerized tomography after unclear results of plain radiography and ultrasonography	2003	The Journal of urology	**I**		DAT
196	Mandhani A;Raghavendran M;Srivastava A;Kapoor R;Singh U;Kumar A;Bhandari M;	Prediction of fragility of urinary calculi by dual X-ray absorptiometry	2003	The Journal of urology	**E**	Not MI	

197	Mendelson RM;rnold-Reed DE;Kuan M;Wedderburn AW;Anderson JE;Sweetman G;Bulsara MK;Mander J;	Renal colic: a prospective evaluation of non-enhanced spiral CT versus intravenous pyelography	2003	Australasian radiology	**I**		CCT
198	Nolte-Ernsting CCA;Staatz G;Tacke J;Gunther RW;	MR urography today	2003	Abdominal Imaging	**E**	No data	
199	Pareek G;Armenakas NA;Fracchia JA;	Hounsfield units on computerized tomography predict stone-free rates after extracorporeal shock wave lithotripsy	2003	Journal of Urology	**I**		case series
200	Parsons JK;Lancini V;Shetye K;Regan F;Potter SR;Jarrett TW;	Urinary stone size: comparison of abdominal plain radiography and noncontrast CT measurements	2003	Journal of endourology / Endourological Society	**I**		DAT
201	Rigas A;Karamanolakis D;Bogdanos I;Stefanidis A;Androulakakis PA;	Pelvi-ureteric junction obstruction by crossing renal vessels: clinical and imaging features	2003	BJU International	**I**		retrospective review
202	Safriel Y;Malhotra A;Sclafani SJ;	Hematuria as an Indicator for the Presence or Absence of Urinary Calculi	2003	American Journal of Emergency Medicine	**I**		retrospective review
203	Tack D;Sourtzis S;Delpierre I;De M;Gevenois PA;	Low-dose unenhanced multidetector CT of patients with suspected renal colic	2003	American Journal of Roentgenology	**I**		DAT

204	Tentolouris N;Charamoglis S;Anastasiou I;Serafetinides E;Mitropoulos D;	The impact of body mass on management of patients with renal colic	2003	International urology and nephrology	**I**		case series
205	Ueda K;Iwasaki S;Nagasawa M;Sueyoshi S;Takahama J;Ide K;Kichikawa K;	Hard-copy versus soft-copy image reading for detection of ureteral stones on abdominal radiography	2003	Radiation medicine	**I**		DAT
206	Van Appledorn S;Ball AJ;Patel VR;Kim S;Leveillee RJ;	Limitations of noncontrast CT for measuring ureteral stones	2003	Journal of endourology / Endourological Society	**E**	No data	
207	Vijayaraghavan SB;Kandasamy SV;Mylsamy A;Prabhakar M;	Sonographic features of necrosed renal papillae causing hydronephrosis	2003	Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine	**E**	PTS CONF	
208	Zielonko J;Studniarek M;Markuszewski M;	MR urography of obstructive uropathy: diagnostic value of the method in selected clinical groups	2003	European Radiology	**E**	NR	
209	Akcar N;Ozkan IR;Adapinar B;Kaya T;	Doppler sonography in the diagnosis of urinary tract obstruction by stone	2004	Journal of clinical ultrasound : JCU	**I**		case-control

210	Ather MH;Faruqui N;Akhtar S;Sulaiman MN;	Is an excretory urogram mandatory in patients with small to medium-sized renal and ureteric stones treated by extra corporeal shock wave lithotripsy?	2004	BMC Medicine	**I**		retrospective case series
211	Ather MH;Jafri AH;Sulaiman MN;	Diagnostic accuracy of ultrasonography compared to unenhanced CT for stone and obstruction in patients with renal failure	2004	BMC Medical Imaging	**I**		DAT
212	Bennett S;Hoffman N;Monga M;	Ephedrine- and guaifenesin-induced nephrolithiasis	2004	Journal of Alternative and Complementary Medicine	**E**	No data	
213	Blandino A;Minutoli F;Scribano E;Vinci S;Magno C;Pergolizzi S;Settineri N;Pandolfo I;Gaeta M;	Combined magnetic resonance urography and targeted helical CT in patients with renal colic: a new approach to reduce delivered dose	2004	Journal of magnetic resonance imaging : JMRI	**I**		DAT
214	bo El-Ghar ME;Shokeir AA;El-Diasty TA;Refaie HF;Gad HM;Shehab El-Dein AB;	Contrast enhanced spiral computerized tomography in patients with chronic obstructive uropathy and normal serum creatinine: A single session for anatomical and functional assessment	2004	Journal of Urology	**E**	Not MI	DAT
215	Browne RFJ;Zwirewich C;Torreggiani WC;	Imaging of urinary tract infection in the adult	2004	European Radiology, Supplement	**E**	No data	

216	Choudhary S;Singh P;Sundar E;Kumar S;Sahai A;	A comparison of sonourethrography and retrograde urethrography in evaluation of anterior urethral strictures	2004	Clinical Radiology	**E**	Not MI	
217	Connolly SS;Younis C;Meade W;Gallagher R;Lovett R;Brady A;Fitzgerald E;Rogers E;Sweeney P;	Can computed tomography in the protocol for renal colic be interpreted by urologists?	2004	BJU international	**I**		DAT
218	El-Ghar MEA;Shokeir AA;El-Diasty TA;Refaie HF;Gad HM;El-Dein ABS;	Contrast enhanced spiral computerized tomography in patients with chronic obstructive uropathy and normal serum creatinine: a single session for anatomical and functional assessment	2004	The Journal of urology	**E**	Not MI	
219	Girish G;Chooi WK;Morcos SK;	Filling defect artefacts in magnetic resonance urography	2004	European Radiology	**E**	NR	
220	Goldman SM;Faintuch S;Ajzen SA;Christofalo DMJ;Araujo MP;Ortiz V;Srougi M;Kenney PJ;Szejnfeld J;	Diagnostic value of attenuation measurements of the kidney on unenhanced helical CT of obstructive ureterolithiasis	2004	AJR American journal of roentgenology	**I**	No data, not MI, but minimal text data regarding GQ 16	retrospective case series
221	Ha M;MacDonald RD;	Impact of CT scan in patients with first episode of suspected nephrolithiasis	2004	Journal of Emergency Medicine	**E**	No data	

222	Kalafatis P;Zougkas K;Petas A;	Primary ureteroscopic treatment for obstructive ureteral stone-causing fornix rupture	2004	International journal of urology : official journal of the Japanese Urological Association	**E**	NR	
223	Karabacakoglu A;Karakose S;Ince O;Cobankara OE;Karalezli G;	Diagnostic value of diuretic-enhanced excretory MR urography in patients with obstructive uropathy	2004	European Journal of Radiology	**I**		DAT
224	Khalaf IM;Shokeir AA;El-Gyoushi FI;Amr HS;Amin MM;	Recoverability of renal function after treatment of adult patients with unilateral obstructive uropathy and normal contralateral kidney: a prospective study	2004	Urology	**I**		prospective study
225	Lin WC;Wang JH;Wei CJ;Chang CY;	Assessment of CT urography in the diagnosis of urinary tract abnormalities	2004	Journal of the Chinese Medical Association : JCMA	**E**	Not MI	
226	Magno C;Blandino A;Anastasi G;Minutoli F;Crea G;Gali A;Caramia M;Melloni D;	Lithiasic obstructive uropathy. Hydronephrosis characterization by magnetic resonance pyelography	2004	Urologia Internationalis	**I**		retrospective study
227	Nadler RB;Stern JA;Kimm S;Hoff F;Rademaker AW;	Coronal imaging to assess urinary tract stone size	2004	The Journal of urology	**I**		retrospective study
228	Noble VE;Brown DFM;	Renal ultrasound	2004	Emergency Medicine Clinics of North America	**E**	No data	

229	Oktar SO;Yucel C;Ozdemir H;Karaosmanoglu D;	Doppler sonography of renal obstruction: value of venous impedance index measurements	2004	Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine	**I**		case-control
230	Oner S;Oto A;Tekgul S;Koroglu M;Hascicek M;Sahin A;Akhan O;	Comparison of spiral CT and US in the evaluation of pediatric urolithiasis	2004	JBR-BTR : organe de la Societe royale belge de radiologie (SRBR) = orgaan van de Koninklijke Belgische Vereniging voor Radiologie (KBVR)	**I**		DAT
231	Ozer C;Yencilek E;Apaydin FD;Nass DM;Yildiz A;Erdem E;Kanik A;Cayan S;	Diagnostic value of renal parenchymal density difference on unenhanced helical computed tomography scan in acutely obstructing ureteral stone disease	2004	Urology	**I**		case-control
232	Parekattil SJ;White MD;Moran ME;Kogan BA;	A computer model to predict the outcome and duration of ureteral or renal calculous passage	2004	The Journal of urology	**I**		retrospective study / statistical modeling
233	Rao PN;	Imaging for kidney stones	2004	World Journal of Urology	**E**	No data	

234	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	2004	European Radiology	**I**		DAT
235	Shokeir AA;El-Diasty T;Eassa W;Mosbah A;El-Ghar MA;Mansour O;Dawaba M;El-Kappany H;	Diagnosis of ureteral obstruction in patients with compromised renal function: The role of noninvasive imaging modalities	2004	Journal of Urology	**I**		DAT
236	Sinha M;Kekre NS;Chacko KN;Devasia A;Lionel G;Pandey AP;Gopalakrishnan G;	Does failure to visualize the ureter distal to an impacted calculus constitute an impediment to successful lithotripsy?	2004	Journal of endourology / Endourological Society	**I**		case series
237	Spencer JA;Chahal R;Kelly A;Taylor K;Eardley I;Lloyd SN;	Evaluation of painful hydronephrosis in pregnancy: magnetic resonance urographic patterns in physiological dilatation versus calculous obstruction	2004	The Journal of urology	**I**		DAT
238	Vrtiska TJ;Lieske JC;	Laboratory and radiographic evaluation	2004	Clinical Reviews in Bone and Mineral Metabolism	**E**	No data	
239	Wang LJ;Ng CJ;Chen JC;Chiu TF;Wong YC;	Diagnosis of acute flank pain caused by ureteral stones: value of combined direct and indirect signs on IVU and unenhanced helical CT	2004	European Radiology	**I**		DAT
240	Zelenko N;Coll D;Rosenfeld AT;Smith RC;	Normal ureter size on unenhanced helical CT	2004	AJR American journal of roentgenology	**E**	No data	

241	Arac M;Celik H;Oner AY;Gultekin S;Gumus T;Kosar S;	Distinguishing pelvic phleboliths from distal ureteral calculi: thin-slice CT findings	2005	European Radiology	**I**		DAT
242	Freeman SJ;Sells H;	Investigation of loin pain	2005	Imaging	**E**	No data	
243	Gaspari RJ;Horst K;	Emergency ultrasound and urinalysis in the evaluation of flank pain	2005	Academic emergency medicine : official journal of the Society for Academic Emergency Medicine	**E**	NR	
244	Gupta NP;Ansari MS;Kesarvani P;Kapoor A;Mukhopadhyay S;	Role of computed tomography with no contrast medium enhancement in predicting the outcome of extracorporeal shock wave lithotripsy for urinary calculi	2005	BJU International	**I**		DAT
245	Kampa RJ;Ghani KR;Wahed S;Patel U;Anson KM;	Size matters: a survey of how urinary-tract stones are measured in the UK	2005	Journal of endourology / Endourological Society	**E**	NR	
246	Kilic S;Altinok MT;Ipek D;Beytur A;Baydinc YC;Gunes G;	Color Doppler sonography examination of partially obstructed kidneys associated with ureteropelvic junction stone before and after percutaneous nephrolithotripsy: preliminary report	2005	International journal of urology : official journal of the Japanese Urological Association	**I**		DAT

247	Kirpalani A;Khalili K;Lee S;Haider MA;	Renal colic: comparison of use and outcomes of unenhanced helical CT for emergency investigation in 1998 and 2002	2005	Radiology	**I**		retrospective review
248	Kocakoc E;Bhatt S;Dogra VS;	Renal multidector row CT	2005	Radiologic Clinics of North America	**E**	No data	
249	Koff SA;Binkovitz L;Coley B;Jayanthi VR;	Renal pelvis volume during diuresis in children with hydronephrosis: Implications for diagnosing obstruction with diuretic renography	2005	Journal of Urology	**I**		DAT
250	Miller FH;Kraemer E;Dalal K;Keppke A;Huo E;Hoff FL;	Unexplained renal colic: what is the utility of IV contrast?	2005	Clinical imaging	**E**	Not MI	
251	Otite U;Parkin J;Waymont B;Inglis JA;Philp NH;	Investigation of acute flank pain: How do practices of U.K. and Irish urologists compare with those of transatlantic and continental European colleagues?	2005	Journal of Endourology	**I**		survey
252	Ozden E;Gogus C;Turkolmez K;Yagci C;	Is fluid ingestion really necessary during ultrasonography for detecting ureteral stones? A prospective randomized study	2005	Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine	**I**		CCT
253	Palmer JS;Donaher ER;O'Riordan MA;Dell KM;	Diagnosis of pediatric urolithiasis: role of ultrasound and computerized tomography	2005	The Journal of urology	**I**		DAT

254	Pareek G;Armenakas NA;Panagopoulos G;Bruno JJ;Fracchia JA;	Extracorporeal shock wave lithotripsy success based on body mass index and Hounsfield units	2005	Urology	**I**		DAT
255	Pareek G;Hedican SP;Lee J;Nakada SY;	Shock wave lithotripsy success determined by skin-to-stone distance on computed tomography	2005	Urology	**I**		DAT
256	Pepe P;Motta L;Pennisi M;Aragona F;	Functional evaluation of the urinary tract by color-Doppler ultrasonography (CDU) in 100 patients with renal colic	2005	European Journal of Radiology	**I**		DAT
257	Regan F;Kuszyk B;Bohlman ME;Jackman S;	Acute ureteric calculus obstruction: unenhanced spiral CT versus HASTE MR urography and abdominal radiograph	2005	The British journal of radiology	**I**		DAT
258	Unal B;Kara S;Bilgili Y;	Contrast media induces hypoperfusion in kidneys with ureteral stone: Doppler US study	2005	Ultrasound in medicine & biology	**I**		case-control
259	Brown J;	Diagnostic and treatment patterns for renal colic in US emergency departments	2006	International Urology and Nephrology	**I**		retrospective review
260	El-Assmy A;El-Nahas AR;Sheir KZ;	Is pre-shock wave lithotripsy stenting necessary for ureteral stones with moderate or severe hydronephrosis?	2006	The Journal of urology	**E**	NR	
261	Gozen AS;Kilic AS;Aktoz T;Akdere H;	Renal anatomical factors for the lower calyceal stone formation	2006	International Urology and Nephrology	**I**		case series

262	Gurel S;Akata D;Gurel K;Ozmen MN;Akhan O;	Correlation between the renal resistive index (RI) and nonenhanced computed tomography in acute renal colic: how reliable is the RI in distinguishing obstruction?	2006	Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine	I		DAT
263	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	2006	The Journal of urology	I		DAT
264	Kartal M;Eray O;Erdogru T;Yilmaz S;	Prospective validation of a current algorithm including bedside US performed by emergency physicians for patients with acute flank pain suspected for renal colic	2006	Emergency Medicine Journal	I		CCT
265	Katz SI;Saluja S;Brink JA;Forman HP;	Radiation dose associated with unenhanced CT for suspected renal colic: impact of repetitive studies	2006	AJR American journal of roentgenology	I		retrospective review
266	Kluner C;Hein PA;Gralla O;Hein E;Hamm B;Romano V;Rogalla P;	Does ultra-low-dose CT with a radiation dose equivalent to that of KUB suffice to detect renal and ureteral calculi?	2006	Journal of Computer Assisted Tomography	I		DAT
267	Kravchick S;Stepnov E;Lebedev V;Linov L;Leibovici O;Ben-Horin CLD;Trejo L;Peled R;Cytron S;	Non-contrast computerized tomography (NCCT) and dynamic renal scintigraphy (DRS) in the patients with refractory renal colic	2006	European Journal of Radiology	I		DAT

268	Poletti PA;Platon A;Rutschmann OT;Verdun FR;Schmidlin FR;Iselin CE;Vermeulen B;Sarasin FP;Buhler LH;Becker CD;	Abdominal plain film in patients admitted with clinical suspicion of renal colic: should it be replaced by low-dose computed tomography?	2006	Urology	**I**		case series
269	Rodgers M;Nixon J;Hempel S;Aho T;Kelly J;Neal D;Duffy S;Ritchie G;Kleijnen J;Westwood M;	Diagnostic tests and algorithms used in the investigation of haematuria: Systematic reviews and economic evaluation	2006	Health Technology Assessment	**E**	Not IP	
270	Seitz C;Fajkovic H;Remzi M;Waldert M;Ozsoy M;Kramer G;Marberger M;	Rapid extracorporeal shock wave lithotripsy treatment after a first colic episode correlates with accelerated ureteral stone clearance	2006	European Urology	**I**		CCT
271	Seitz C;Fajkovic H;Waldert M;Tanovic E;Remzi M;Kramer G;Marberger M;	Extracorporeal shock wave lithotripsy in the treatment of proximal ureteral stones: Does the presence and degree of hydronephrosis affect success?	2006	European Urology	**I**		DAT
272	Shen S;Wang J;Huang S;Chang C;	Can intravenous urography be replaced by CT urography? Our experience in the evaluation for hematuria	2006	Chinese Journal of Radiology	**E**	Not IP	

273	Wendt-Nordahl G;Rotert H;Trojan L;Michel MS;Peters CR;Alken P;Knoll T;	Intravenous contrast media in uroradiology: evaluation of safety and tolerability in almost 50,000 patients	2006	Medical principles and practice : international journal of the Kuwait University, Health Science Centre	**I**		Other: multicentre postmarketing surveillance study
274	Yoshida S;Hayashi T;Ikeda J;Yoshinaga A;Ohno R;Ishii N;Okada T;Osada H;Honda N;Yamada T;	Role of volume and attenuation value histogram of urinary stone on noncontrast helical computed tomography as predictor of fragility by extracorporeal shock wave lithotripsy	2006	Urology	**I**		DAT
275	Bartoletti R;Cai T;Mondaini N;Melone F;Travaglini F;Carini M;Rizzo M;	Epidemiology and risk factors in urolithiasis	2007	Urologia Internationalis	**E**	No data	
276	Broder J;Bowen J;Lohr J;Babcock A;Yoon J;	Cumulative CT exposures in emergency department patients evaluated for suspected renal colic	2007	The Journal of emergency medicine	**I**		retrospective review
277	Chowdhury FU;Kotwal S;Raghunathan G;Wah TM;Joyce A;Irving HC;	Unenhanced multidetector CT (CT KUB) in the initial imaging of suspected acute renal colic: evaluating a new service	2007	Clinical Radiology	**I**		retrospective review

278	Eikefjord EN;Thorsen F;Rorvik J;	Comparison of effective radiation doses in patients undergoing unenhanced MDCT and excretory urography for acute flank pain	2007	AJR American journal of roentgenology	**I**		case series
279	El-Assmy A;El-Nahas AR;Youssef RF;El-Hefnawy AS;Sheir KZ;	Impact of the degree of hydronephrosis on the efficacy of in situ extracorporeal shock-wave lithotripsy for proximal ureteral calculi	2007	Scandinavian journal of urology and nephrology	**E**	Other: patient group replicated	
280	El-Assmy A;El-Nahas AR;Youssef RF;El-Hefnawy AS;Sheir KZ;	Does degree of hydronephrosis affect success of extracorporeal shock wave lithotripsy for distal ureteral stones?	2007	Urology	**I**		DAT
281	Lin EP;Bhatt S;Dogra VS;Rubens DJ;	Sonography of Urolithiasis and Hydronephrosis	2007	Ultrasound Clinics	**E**	No data	
282	Lin W;Uppot RN;Li C;Hahn PF;Sahani DV;	Value of Automated Coronal Reformations From 64-Section Multidetector Row Computerized Tomography in the Diagnosis of Urinary Stone Disease	2007	Journal of Urology	**I**		DAT
283	Memarsadeghi M;Schaefer-Prokop C;Prokop M;Helbich TH;Seitz CC;Noebauer-Huhmann IM;Heinz-Peer G;	Unenhanced MDCT in patients with suspected urinary stone disease: do coronal reformations improve diagnostic performance?	2007	AJR American journal of roentgenology	**I**		retrospective study

284	Mitterberger M;Pinggera GM;Maier E;Neuwirt H;Neururer R;Pallwein L;Gradl J;Bartsch G;Strasser H;Frauscher F;	Value of 3-dimensional transrectal/transvaginal sonography in diagnosis of distal ureteral calculi	2007	Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine	I		prospective study
285	Mitterberger M;Pinggera GM;Pallwein L;Gradl J;Feuchtner G;Plattner R;Neururer R;Bartsch G;Strasser H;Frauscher F;	Plain abdominal radiography with transabdominal native tissue harmonic imaging ultrasonography vs unenhanced computed tomography in renal colic	2007	BJU International	I		DAT
286	Mulkens TH;Daineffe S;De Wijngaert R;Bellinck P;Leonard A;Smet G;Termote JL;	Urinary stone disease: comparison of standard-dose and low-dose with 4D MDCT tube current modulation	2007	AJR American journal of roentgenology	I		DAT
287	Onur MR;Cubuk M;Andic C;Kartal M;Arslan G;	Role of resistive index in renal colic	2007	Urological Research	I		DAT
288	Perks AE;Gotto G;Teichman JMH;	Shock Wave Lithotripsy Correlates With Stone Density on Preoperative Computerized Tomography	2007	Journal of Urology	I		retrospective study
289	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	2007	AJR American journal of roentgenology	I		DAT
290	Saboo SS;Soni SS;Saboo SH;Chinapuvvula NR;Kaza S;	Doppler sonography in acute renal obstruction	2007	Indian Journal of Radiology and Imaging	I		DAT

291	Scheffel H;Stolzmann P;Frauenfelder T;Schertler T;Desbiolles L;Leschka S;Marincek B;Alkadhi H;	Dual-energy contrast-enhanced computed tomography for the detection of urinary stone disease	2007	Investigative Radiology	**E**	Not MI	DAT
292	Seitz C;Tanovic E;Kikic Z;Fajkovic H;	Impact of stone size, location, composition, impaction, and hydronephrosis on the efficacy of holmium:YAG-laser ureterolithotripsy	2007	European Urology	**I**		case series
293	Shrotri KN;Morrison ID;Shrotri NC;	Urological conditions in pregnancy: a diagnostic and therapeutic challenge	2007	Journal of obstetrics and gynaecology : the journal of the Institute of Obstetrics and Gynaecology	**E**	No data	
294	Tisdale BE;Siemens DR;Lysack J;Nolan RL;Wilson JW;	Correlation of CT scan versus plain radiography for measuring urinary stone dimensions	2007	The Canadian journal of urology	**I**		retrospective review
295	Turrin A;Minola P;Costa F;Cerati L;Andrulli S;Trinchieri A;	Diagnostic value of colour Doppler twinkling artefact in sites negative for stones on B mode renal sonography	2007	Urological Research	**I**		DAT
296	Uraiqat A;Al KM;Al SJ;	Non-enhanced spiral CT versus excretory urography in acute renal colic	2007	Qatar Medical Journal	**E**	Other: no article	
297	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	2007	Journal of endourology / Endourological Society	**I**		DAT

298	Wolf J;	Treatment Selection and Outcomes: Ureteral Calculi	2007	Urologic Clinics of North America	**E**	No data	
299	Abdelrahim AF;Abdelmaguid A;Abuzeid H;Amin M;Mousa ES;Abdelrahim F;	Rigid ureteroscopy for ureteral stones: factors associated with intraoperative adverse events	2008	Journal of endourology / Endourological Society	**E**	NR	
300	Chan VO;Buckley O;Persaud T;Torreggiani WC;	Urolithiasis: how accurate are plain radiographs?	2008	Canadian Association of Radiologists journal = Journal l'Association canadienne des radiologistes	**I**		retrospective study
301	Chen MM;Coakley FV;Kaimal A;Laros RK;	Guidelines for computed tomography and magnetic resonance imaging use during pregnancy and lactation	2008	Obstetrics and Gynecology	**E**	No data	
302	Cullen IM;Cafferty F;Oon SF;Manecksha R;Shields D;Grainger R;McDermott TED;Plunkett P;Meaney J;Lynch TH;	Evaluation of suspected renal colic with noncontrast CT in the emergency department: a single institution study	2008	Journal of endourology / Endourological Society	**I**		retrospective study
303	Cupisti A;Pasquali E;Lusso S;Carlino F;Orsitto E;Melandri R;	Renal colic in Pisa emergency department: epidemiology, diagnostics and treatment patterns	2008	Internal and emergency medicine	**I**		retrospective review

304	de Bessa J Jr;Denes FT;Chammas MC;Cerri L;Monteiro EDS;Buchpiguel CA;Cerri GG;Srougi M;	Diagnostic accuracy of color Doppler sonographic study of the ureteric jets in evaluation of hydronephrosis	2008	Journal of pediatric urology	**I**		DAT
305	de Bessa JJ;Denes FT;Chammas MC;Cerri L;Schneider Monteiro ED;Buchpiguel CA;Cerri GG;Srougi M;	Diagnostic accuracy of color Doppler sonographic study of the ureteric jets in evaluation of hydronephrosis	2008	Journal of Pediatric Urology	**E**	Other: no article	
306	Eisner BH;Pedro R;Namasivayam S;Kambadakone A;Sahani DV;Dretler SP;Monga M;	Differences in stone size and ureteral dilation between obstructing proximal and distal ureteral calculi	2008	Urology	**I**		retrospective study
307	Elwagdy S;Ghoneim S;Moussa S;Ewis I;	Three-dimensional ultrasound (3D US) methods in the evaluation of calcular and non-calcular ureteric obstructive uropathy	2008	World Journal of Urology	**I**		prospective study
308	Furlan A;Federle MP;Yealy DM;Averch TD;Pealer K;	Nonobstructing renal stones on unenhanced CT: a real cause for renal colic?	2008	AJR American journal of roentgenology	**I**		retrospective study
309	Graser A;Johnson TRC;Bader M;Staehler M;Haseke N;Nikolaou K;Reiser MF;Stief CG;Becker CR;	Dual energy CT characterization of urinary calculi: initial in vitro and clinical experience	2008	Investigative radiology	**I**		DAT
310	Gurocak S;Kupeli B;Acar C;Tan MO;Karaoglan U;Bozkirli I;	The impact of pelvicaliceal features on problematic lower pole stone clearance in different age groups	2008	International Urology and Nephrology	**E**	NR	

311	Hsiao HL;Huang SP;Wu WJ;Lee YC;Li WM;Chou YH;Chang AW;Huang CH;Sun SC;Liu CC;	Impact of hydronephrosis on treatment outcome of solitary proximal ureteral stone after extracorporeal shock wave lithotripsy	2008	The Kaohsiung journal of medical sciences	I		DAT
312	John BS;Patel U;Anson K;	What radiation exposure can a patient expect during a single stone episode?	2008	Journal of endourology / Endourological Society	I		retrospective study
313	Juan YS;Huang CH;Wang CJ;Chou YH;Chuang SM;Li CC;Shen JT;Wu WJ;	Predictive role of renal resistance indices in the extracorporeal shock-wave lithotripsy outcome of ureteral stones	2008	Scandinavian journal of urology and nephrology	I		DAT
314	Kacker R;Zhao L;Macejko A;Thaxton CS;Stern J;Liu JJ;Nadler RB;	Radiographic Parameters on Noncontrast Computerized Tomography Predictive of Shock Wave Lithotripsy Success	2008	Journal of Urology	I		retrospective case series
315	Kennish SJ;Bhatnagar P;Wah TM;Bush S;Irving HC;	Is the KUB radiograph redundant for investigating acute ureteric colic in the non-contrast enhanced computed tomography era?	2008	Clinical Radiology	I		retrospective review
316	Kishore TA;Pedro RN;Hinck B;Monga M;	Estimation of size of distal ureteral stones: noncontrast CT scan versus actual size	2008	Urology	I		DAT
317	Lamb ADG;Wines MD;Mousa S;Tolley DA;	Plain radiography still is required in the planning of treatment for urolithiasis	2008	Journal of endourology / Endourological Society	I		case series

318	Leijte JAP;Oddens JR;Lock TMTW;	Holmium laser lithotripsy for ureteral calculi: predictive factors for complications and success	2008	Journal of endourology / Endourological Society	**I**		retrospective review
319	Lin C;Hsu Y;Chen K;	Predictive factors of lower calyceal stone clearance after Extracorporeal Shockwave Lithotripsy (ESWL): The impact of radiological anatomy	2008	Journal of the Chinese Medical Association	**I**		retrospective review
320	O'Connor OJ;McSweeney SE;Maher MM;	Imaging of Hematuria	2008	Radiologic Clinics of North America	**E**	Not IP	
321	Park SJ;Yi BH;Lee HK;Kim YH;Kim GJ;Kim HC;	Evaluation of patients with suspected ureteral calculi using sonography as an initial diagnostic tool: how can we improve diagnostic accuracy?	2008	Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine	**I**		DAT
322	Reddy S;	State of the art trends in imaging renal of colic	2008	Emergency Radiology	**E**	No data	
323	Ritchie G;Wilkinson AG;Prescott RJ;	Comparison of differential renal function using technetium-99m mercaptoacetyltriglycine (MAG3) and technetium-99m dimercaptosuccinic acid (DMSA) renography in a paediatric population	2008	Pediatric Radiology	**E**	NR	

324	Seitz C;Memarsadeghi M;Fajkovic H;Tanovic E;	Secondary signs of non-enhanced CT prior to laser ureterolithotripsy: is treatment outcome predictable?	2008	Journal of endourology / Endourological Society	**I**		case series
325	Sen KK;Mohan C;Verma BS;	Magnetic resonance urography in obstructive uropathy	2008	Medical Journal Armed Forces India	**I**		DAT
326	Seong JP;Boem HY;Hae KL;Young HK;Gong JK;Hyun CK;	Evaluation of patients with suspected ureteral calculi using sonography as an initial diagnostic tool: How can we improve diagnostic accuracy?	2008	Journal of Ultrasound in Medicine	**E**	Other: replicated	
327	Sighinolfi MC;Micali S;De Stefani S;Saredi G;Mofferdin A;Grande M;Bianchi G;	Noninvasive management of obstructing ureteral stones using electromagnetic extracorporeal shock wave lithotripsy	2008	Surgical endoscopy	**I**		CCT
328	Tiselius HG;	How efficient is extracorporeal shockwave lithotripsy with modern lithotripters for removal of ureteral stones?	2008	Journal of endourology / Endourological Society	**I**		case series
329	Ulahannan D;Blakeley CJ;Jeyadevan N;Hashemi K;	Benefits of CT urography in patients presenting to the emergency department with suspected ureteric colic	2008	Emergency medicine journal : EMJ	**I**		case series
330	Wadhera S;Mathur RK;Odiya S;Raikwar RS;Girish G;	Solo extracorporeal shock wave lithotripsy for management of upper ureteral calculi with hydronephrosis	2008	Urology journal	**I**		DAT

331	Wang JH;Shen SH;Huang SS;Chang CY;	Prospective comparison of unenhanced spiral computed tomography and intravenous urography in the evaluation of acute renal colic	2008	Journal of the Chinese Medical Association : JCMA	I		DAT
332	Alshamakhi AK;Barclay LC;Halkett G;Kukade G;Mundhada D;Uppoor RR;Gawai P;	CT evaluation of flank pain and suspected urolithiasis	2009	Radiologic technology	I		DAT
333	Andreoiu M;MacMahon R;	Renal colic in pregnancy: lithiasis or physiological hydronephrosis?	2009	Urology	I		retrospective review
334	Ather MH;Faizullah K;Achakzai I;Siwani R;Irani F;	Alternate and incidental diagnoses on noncontrast-enhanced spiral computed tomography for acute flank pain	2009	Urology journal	I		retrospective review
335	Bandi G;Meiners RJ;Pickhardt PJ;Nakada SY;	Stone measurement by volumetric three-dimensional computed tomography for predicting the outcome after extracorporeal shock wave lithotripsy	2009	BJU International	I		retrospective study
336	Bhuskute NM;Yap WW;Wah TM;	A retrospective evaluation of Randall's plaque theory of nephrolithiasis with CT attenuation values	2009	European Journal of Radiology	I		retrospective study
337	Bozgeyik Z;Kocakoc E;Sonmezgoz F;	Diffusion-weighted MR imaging findings of kidneys in patients with early phase of obstruction	2009	European Journal of Radiology	I		case series

338	Ciaschini MW;Remer EM;Baker ME;Lieber M;Herts BR;	Urinary calculi: Radiation dose reduction of 50% and 75% at CT - Effect on sensitivity	2009	Radiology	**I**		simulated DAT
339	Granata A;Andrulli S;Bigi MQ;Pozzoni P;Fiorini F;Logias F;Figuera M;Basile A;Fiore CE;	Predictive role of duplex Doppler ultrasonography in the diagnosis of acute renal obstruction in patients with unilateralrenal colic	2009	Clinical Nephrology	**I**		DAT
340	Hamzaini AH;Helmee MN;Masoud S;Suraya A;Nazri MSJ;Das S;	The predictive values of urinalysis in intravenous urogram. Is intravenous urography really necessary in mild hydronephrotic patient?	2009	Clinica Terapeutica	**E**	NR	
341	Hong YK;Park DS;	Ureteroscopic lithotripsy using Swiss Lithoclast for treatment of ureteral calculi: 12-years experience	2009	Journal of Korean medical science	**I**		case series
342	Hosseini MM;Hassanpour A;Farzan R;Yousefi A;Afrasiabi MA;	Ultrasonography-guided percutaneous nephrolithotomy	2009	Journal of Endourology	**E**	NR	
343	Huang CC;Chuang CK;Wong YC;Wang LJ;Wu CH;	Useful prediction of ureteral calculi visibility on abdominal radiographs based on calculi characteristics on unenhanced helical CT and CT scout radiographs	2009	International Journal of Clinical Practice	**I**		retrospective study

344	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	2009	AJR American journal of roentgenology	**I**		DAT
345	Lam CW;Lan L;Che X;Tam S;Wong SS;Chen Y;Jin J;Tao SH;Tang XM;Yuen KY;Tam PK;	Diagnosis and spectrum of melamine-related renal disease: plausible mechanism of stone formation in humans	2009	Clinica chimica acta; international journal of clinical chemistry	**E**	NR	
346	Macejko A;Okotie OT;Zhao LC;Liu J;Perry K;Nadler RB;	Computed tomography-determined stone-free rates for ureteroscopy of upper-tract stones	2009	Journal of endourology / Endourological Society	**I**		case series
347	Marickar YMF;Salim A;	Temporary risk identification in urolithiasis	2009	Urological Research	**E**	NR	
348	Ng CF;Siu DY;Wong A;Goggins W;Chan ES;Wong KT;	Development of a scoring system from noncontrast computerized tomography measurements to improve the selection of upper ureteral stone for extracorporeal shock wave lithotripsy	2009	The Journal of urology	**I**		case series
349	Oon S;Mulvin D;Mealy K;	Managing ureteric colic in a smaller hospital without urological support	2009	Irish Medical Journal	**E**	NR	

350	Passerotti C;Chow JS;Silva A;Schoettler CL;Rosoklija I;Perez-Rossello J;Cendron M;Cilento BG;Lee RS;Nelson CP;Estrada CR;Bauer SB;Borer JG;Diamond DA;Retik AB;Nguyen HT;	Ultrasound versus computerized tomography for evaluating urolithiasis	2009	The Journal of urology	**I**		DAT
351	Patel SR;Haleblian G;Zabbo A;Pareek G;	Hounsfield units on computed tomography predict calcium stone subtype composition	2009	Urologia Internationalis	**I**		retrospective study
352	Pathak S;Lavin V;Vijay R;Basu S;Salim F;Collins M;Hastie K;Hall J;	Radiological determination of stone density and skin-to-stone distance-Can it predict the success of extracorporeal shock wave lithotripsy?	2009	British Journal of Medical and Surgical Urology	**I**		retrospective study
353	Persaud AC;Stevenson MD;McMahon DR;Christopher NC;	Pediatric urolithiasis: clinical predictors in the emergency department	2009	Pediatrics	**I**		retrospective study
354	Salem HK;	A prospective randomized study comparing shock wave lithotripsy and semirigid ureteroscopy for the management of proximal ureteral calculi	2009	Urology	**I**		CCT
355	Singh S;Chowdhury V;	Radiological investigations in urolithiasis	2009	Journal International Medical Sciences Academy	**E**	Other: no article	

356	Tealab AA;Ihab I;Maarouf AM;Mohamed M;Said AEM;Fatma Z;	The role of unenhanced spiral computerized tomography in prediction of successful fragmentation of the renal calculus by extracorporeal shock wave lithotripsy	2009	Current Urology	I		case series
357	Thoeny HC;Binser T;Roth B;Kessler TM;Vermathen P;	Noninvasive assessment of acute ureteral obstruction with diffusion-weighted MR imaging: a prospective study	2009	Radiology	I		case series
358	Thomas C;Patschan O;Ketelsen D;Tsiflikas I;Reimann A;Brodoefel H;Buchgeister M;Nagele U;Stenzl A;Claussen C;Kopp A;Heuschmid M;Schlemmer H;	Dual-energy CT for the characterization of urinary calculi: In vitro and in vivo evaluation of a low-dose scanning protocol	2009	European Radiology	I		retrospective study
359	Vakalopoulos I;	Development of a mathematical model to predict extracorporeal shockwave lithotripsy outcome	2009	Journal of endourology / Endourological Society	I		statistical modeling
360	Varma G;Nair N;Salim A;Fazil Marickar YM;	Investigations for recognizing urinary stone	2009	Urological Research	I		DAT
361	Youssef RF;El-Nahas AR;El-Assmy AM;El-Tabey NA;El-Hefnawy AS;Eraky I;El-Kenawy MR;El-Kappany HA;Sheir KZ;	Shock Wave Lithotripsy Versus Semirigid Ureteroscopy for Proximal Ureteral Calculi (<20 mm): A Comparative Matched-pair Study	2009	Urology	I		retrospective case series

362	Zagoria RJ;Dixon RL;	Radiology of urolithiasis: implications of radiation exposure and new imaging modalities	2009	Advances in chronic kidney disease	**E**	No data	
363	Zhu S;Li J;Chen L;Bao Z;Zhang L;Li J;Chen J;Ji K;	Conservative management of pediatric nephrolithiasis caused by melamine-contaminated milk powder	2009	Pediatrics	**E**	NR	
364	Ahmed F;Zafar AM;Khan N;Haider Z;Ather MH;	A paradigm shift in imaging for renal colic - Is it time to say good bye to an old trusted friend?	2010	International journal of surgery (London, England)	**I**		retrospective case series
365	Ascenti G;Siragusa C;Racchiusa S;Ielo I;Privitera G;Midili F;Mazziotti S;	Stone-targeted dual-energy CT: a new diagnostic approach to urinary calculosis	2010	AJR American journal of roentgenology	**I**		DAT
366	Ben Nakhi A;Gupta R;Al-Hunayan A;Muttikkal T;Chavan V;Mohammed A;Ali Y;	Comparative analysis and interobserver variation of unenhanced computed tomography and intravenous urography in the diagnosis of acute flank pain	2010	Medical principles and practice : international journal of the Kuwait University, Health Science Centre	**I**		DAT
367	Ciftci H;Cece H;Dusak A;Savas M;Verit A;Yeni E;	Study of the ureterovesical jet flow by means of dupplex Doppler ultrasonography in patients with residual ureteral stone after extracorporeal shock wave lithotripsy	2010	Urological Research	**I**		case series

368	Edmonds ML;Yan JW;Sedran RJ;McLeod SL;Theakston KD;	The utility of renal ultrasonography in the diagnosis of renal colic in emergency department patients	2010	CJEM : Canadian journal of emergency medical care = JCMU : journal canadien de soins medicaux d'urgence	**I**		retrospective case series
369	Elgamasy A;Elsherif A;	Use of Doppler ultrasonography and rigid ureteroscopy for managing symptomatic ureteric stones during pregnancy	2010	BJU International	**I**		case series
370	Goertz JK;Lotterman S;	Can the degree of hydronephrosis on ultrasound predict kidney stone size?	2010	The American journal of emergency medicine	**I**		retrospective review
371	Goldstone A;Bushnell A;	Does diagnosis change as a result of repeat renal colic computed tomography scan in patients with a history of kidney stones?	2010	The American journal of emergency medicine	**I**		retrospective review
372	Griffin SJ;Margaryan M;Archambaud F;Sergent-Alaoui A;Lottmann HB;	Safety of shock wave lithotripsy for treatment of pediatric urolithiasis: 20-year experience	2010	The Journal of urology	**I**		retrospective study
373	Hadzhiyska V;Petrov T;Kostadinova I;Mladenov V;Marianovski V;Stoinova V;	A new imaging method of multimodal diagnostic in patients with urolithiasis	2010	European Urology, Supplements	**E**	No data	

374	Hu H;Hu X;Fang X;Chen H;Yao X;	Unenhanced helical CT following excretory urography in the diagnosis of upper urinary tract disease: A little more cost, a lot more value	2010	Urological Research	**I**		DAT
375	Hwang E;Kim YH;Yuk SM;Sul CK;Lim JS;	Factors that predict spontaneous passage of a small distal ureteral stone <5 mm	2010	Journal of endourology / Endourological Society	**I**		case series
376	Jang TB;Casey RJ;Dyne P;Kaji A;	The learning curve of resident physicians using emergency ultrasonography for obstructive uropathy	2010	Academic emergency medicine : official journal of the Society for Academic Emergency Medicine	**E**	NR	case series
377	Jung S Ii;Kim YJ;Park HS;Jeon HJ;Park HK;Paick SH;Kim HG;Lho YS;	Sensitivity of digital abdominal radiography for the detection of ureter stones by stone size and location	2010	Journal of Computer Assisted Tomography	**I**		retrospective study
378	Kameda T;Kawai F;Taniguchi N;Mori I;Ono M;Tsukahara N;Kobori Y;Yoshida H;Wagai K;Numao A;	Ultrasonography for ureteral stone detection in patients with or without caliceal dilatation	2010	Journal of Medical Ultrasonics	**I**		case series
379	Kang IS;Lee JW;Seo IY;	Urinary stone assessment with dual energy computed tomography in human	2010	Journal of Endourology	**E**	Other: no article	
380	Kennish SJ;Wah TM;Irving HC;	Unenhanced CT for the evaluation of acute ureteric colic: the essential pictorial guide	2010	Postgraduate medical journal	**E**	No data	

381	Kim HC;Yang DM;Jin W;Ryu JK;Shin HC;	Color Doppler twinkling artifacts in various conditions during abdominal and pelvic sonography	2010	Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine	**E**	No data	
382	Kumar A;Mohanty NK;Jain M;Prakash S;Arora RP;	A prospective randomized comparison between early (<48 hours of onset of colicky pain) versus delayed shockwave lithotripsy for symptomatic upper ureteral calculi: a single center experience	2010	Journal of endourology / Endourological Society	**I**		CCT
383	Mahgerefteh S;Blachar A;Fraifeld S;Sosna J;	Dual-Energy Derived Virtual Nonenhanced Computed Tomography Imaging: Current Status and Applications	2010	Seminars in Ultrasound, CT and MRI	**E**	No data	
384	Mancini JG;Ferrandino MN;	The impact of new methods of imaging on radiation dosage delivered to patients	2010	Current Opinion in Urology	**E**	No data	
385	Mermuys K;De GF;Bacher K;Van De MK;Coenegrachts K;Steyaert L;Casselman JW;	Digital tomosynthesis in the detection of urolithiasis: Diagnostic performance and dosimetry compared with digital radiography with MDCT as the reference standard	2010	American Journal of Roentgenology	**E**	Not MI	prospective study
386	Mos C;Holt G;Iuhasz S;Mos D;Teodor I;Halbac M;	The sensitivity of transabdominal ultrasound in the diagnosis of ureterolithiasis	2010	Medical ultrasonography	**I**		DAT

387	Pabon-Ramos W;Caoili E;Cohan R;Stephens T;Francis I;Ellis J;Korobkin M;Schipper M;	Excretory urography: Trends in clinical use and diagnostic yield	2010	Abdominal Imaging	**I**		retrospective review
388	Ray AA;Ghiculete D;Pace KT;Honey RJD;	Limitations to ultrasound in the detection and measurement of urinary tract calculi	2010	Urology	**I**		retrospective review / meta-analysis
389	Routh JC;Graham DA;Nelson CP;	Trends in imaging and surgical management of pediatric urolithiasis at American pediatric hospitals	2010	The Journal of urology	**I**		retrospective review
390	Saeed R;Al-Saeed O;Athyal R;Yadav C;	Value of kidney-ureter-bladder radiography in the erect position in addition to standard intravenous urography examination	2010	Medical principles and practice : international journal of the Kuwait University, Health Science Centre	**E**	No data	DAT
391	Shah K;Kurien A;Mishra S;Ganpule A;Muthu V;Sabnis RB;Desai M;	Predicting effectiveness of extracorporeal shockwave lithotripsy by stone attenuation value	2010	Journal of endourology / Endourological Society	**I**		case series
392	Sun DQ;Zhang XF;Zhang L;Feng H;Yang YH;	The clinical analysis of young children's urolithiasis due to melamine-tainted infant formula	2010	World Journal of Urology	**E**	NR	

393	Thomas C;Heuschmid M;Schilling D;Ketelsen D;Tsiflikas I;Stenzl A;Claussen CD;Schlemmer H;	Urinary calculi composed of uric acid, cystine, and mineral salts: Differentiation with dual-energy CT at a radiation dose comparable to that of intravenous pyelography	2010	Radiology	**I**		retrospective case series
394	Turunc T;Gonen M;Kuzgunbay B;Bilgilisoy UT;Dirim A;Tekin MI;Ozkardes H;	The effects of hydronephrosis and stone burden on success rates of shockwave lithotripsy in pediatric population	2010	Journal of Endourology	**I**		case series
395	Turunc T;Kuzgunbay B;Gul U;Kayis AA;Bilgilisoy UT;Aygun C;Ozkardes H;	Factors affecting the success of ureteroscopy in management of ureteral stone diseases in children	2010	Journal of endourology / Endourological Society	**I**		retrospective case series
396	Yazdi HR;Mirjalili M;Noroozi R;	Twinkling artifact in patients with urinary stones	2010	Iranian Journal of Radiology	**I**		case series
397	Zhu Z;Xi Q;Wang S;Liu J;Ye Z;Yu X;Bai J;Li C;	Percutaneous nephrolithotomy for proximal ureteral calculi with severe hydronephrosis: assessment of different lithotriptors	2010	Journal of endourology / Endourological Society	**E**	NR	
398	Zilberman DE;Ferrandino MN;Preminger GM;Paulson EK;Lipkin ME;Boll DT;	In vivo determination of urinary stone composition using dual energy computerized tomography with advanced post-acquisition processing	2010	Journal of Urology	**I**		case series

399	Zomorrodi A;Buhluli A;Fathi S;	Anatomy of the collecting system of lower pole of the kidney in patients with a single renal stone: a comparative study with individuals with normal kidneys	2010	Saudi journal of kidney diseases and transplantation : an official publication of the Saudi Center for Organ Transplantation, Saudi Arabia	**I**		retrospective cross-sectional case control study
400	Abujudeh HH;Kaewlai R;McMahon PM;Binder W;Novelline RA;Gazelle GS;Thrall JH;	Abdominopelvic CT increases diagnostic certainty and guides management decisions: a prospective investigation of 584 patients in a large academic medical center	2011	AJR American journal of roentgenology	**I**		Other: Descriptive investigation of case series
401	Fowler JC;Cutress ML;Abubacker Z;Saleemi MA;Alam A;Shekhdar J;Wagstaff H;	Clinical evaluation of ultra-low dose contrast-enhanced CT in patients presenting with acute ureteric colic	2011	British Journal of Medical and Surgical Urology	**I**		DAT
402	Gurbuz C;Best SL;Donnally C;Mir S;Pearle MS;Cadeddu JA;	Intermediate term outcomes associated with the surveillance of ureteropelvic junction obstruction in adults	2011	Journal of Urology	**E**	Not IP	
403	Nikolic O;Stojanovic S;Till V;Nikolic MB;Petrovic K;Cirilovic VV;	Multislice computed tomography urography in the diagnosis of urinary tract diseases	2011	Vojnosanitetski Pregled	**E**	Not IP	

404	Quirke M;Divilly F;O'Kelly P;Winder S;Gilligan P;	Imaging patients with renal colic: a comparative analysis of the impact of non-contrast helical computed tomography versus intravenous pyelography on the speed of patient processing in the Emergency Department	2011	Emergency medicine journal : EMJ	**I**		retrospective cohort with comparison
405	Sataa S;Kerim C;Sami BR;Nizar D;Rochdi E;Nidhameddine K;Ali H;	Giant hydronephrosis in adults: What is the best approach? retrospective analysis of 24 cases	2011	Nephro-Urology Monthly	**E**	No data	
406	Seo IY;Lee JW;Rim JS;	Identification of uric acid stone with dual energy computed tomography in human	2011	Journal of Urology	**E**	Other: no article	
407	Siddiqui MM;McDougal WS;	Urologic assessment of decreasing renal function	2011	Medical Clinics of North America	**E**	No data	
408	Unsal A;Caliskan EK;Erol H;Karaman CZ;	The diagnostic efficiency of ultrasound guided imaging algorithm in evaluation of patients with hematuria	2011	European Journal of Radiology	**E**	Not IP	
409	Wang M;Shi Q;Wang X;Yang K;Yang R;	Prediction of outcome of extracorporeal shock wave lithotripsy in the management of ureteric calculi	2011	Urological Research	**I**		retrospective case series
410	Wiesenthal JD;Ghiculete D;Ray AA;Honey RJD';Pace KT;	A clinical nomogram to predict the successful shock wave lithotripsy of renal and ureteral calculi	2011	Journal of Urology	**I**		retrospective case series

411	Zilberman DE;Tsivian M;Lipkin ME;Ferrandino MN;Frush DP;Paulson EK;Preminger GM;	Low dose computerized tomography for detection of urolithiasis--its effectiveness in the setting of the urology clinic	2011	The Journal of urology	I		DAT

Appendix E. QUADAS Ratings of Diagnostic Accuracy Studies

Supplementary Table 4. QUADAS instrument evaluation of studies utilizing non-contrast CT as the gold standard.

QUADAS Tool – Questions	Levine et al. 1997 (#067)	Eray et al. 2003 (#187)	Pepe et al. 2005 (#256)	Poletti et al. 2007 (#289)	Chan et al. 2008 (#300)	Passerotti et al. 2009 (#350)	Ben Nakhi et al. 2010 (#366)	Jung et al. 2010 (#377)
1. Was the spectrum of patients representative of the patients who will receive the test in practice? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Were selection criteria clearly described? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Is reference standard likely to correctly classify the target condition? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Is the time period between reference standard and index test short enough to be reasonably sure that the target condition did not change between the two tests? Yes/No/Unclear	No	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes
5. Did the whole sample or a random selection of the sample, receive verification using a reference standard of diagnosis? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Did patients receive the same reference standard regardless of the index test result? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Was the reference standard independent of the index test (i.e. the index test did not form part of the reference standard)? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

QUADAS Tool – Questions	Levine et al. 1997 (#067)	Eray et al. 2003 (#187)	Pepe et al. 2005 (#256)	Poletti et al. 2007 (#289)	Chan et al. 2008 (#300)	Passerotti et al. 2009 (#350)	Ben Nakhi et al. 2010 (#366)	Jung et al. 2010 (#377)
8. Was the execution of the index test described in sufficient detail to permit replication of the test? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9. Was the execution of the reference standard described in sufficient detail to permit its replication? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10. Were the index test results interpreted without knowledge of the results of the reference standard? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11. Were the reference standard results interpreted without knowledge of the results of the index test? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12. Were the same clinical data available when test results were interpreted as would be available when the test is used in practice? Yes/No/Unclear	No	Yes	Yes	No	No	Yes	Unclear	No
13. Were uninterpretable/intermediate results reported? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14. Were withdrawals from the study explained? Yes/No/Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes