Can we really call it lithiasis? A young radiologist guide

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Learning objectives

Provide a guide for the young radiologist (UL) in urolithiasis imaging.

Background

UL is a universal problem with a high rate of recurrence.

Imaging has evolved over the years with CT considered gold standard.

Findings and procedure details

UL is a universal problem with a high rate of recurrence.

Imaging has evolved over the years with CT considered gold standard.

Results

During US, ecoghenic sinusal foci are common and the YR faces the dilemma " Stones ?".

A systematic approach helps with inevitable difficulties along the way.

There are common sites for stones impaction with different symptoms, the ureteropelvic junction (UPJ), the ureterovesical junction (UVJ) and near common iliac artery bifurcation.

Stone location, size, and composition must be reported.

Incorrect CT parameters may produce false negatives and affect measurements.

ACR Appropriateness Criteria Pain-Suspicion of Stone Disease Clinical Condition: Acute Onset Flank Pain-Suspicion of Stone Disease (Urolithiasis)

CT abdomen and pelvis without IV contrast	8	Reduced-dose techniques are preferred.	####
CT abdomen and pelvis without and with IV contrast	6	This procedure is indicated if CT without contrast does not explain pain or reveals an abnormality that should be further assessed with contrast (eg, stone versus phleboliths).	####
US color Doppler kidneys and bladder retroperitoneal	6		O

X-ray intravenous urography	4		###
MRI abdomen and pelvis without IV contrast	4	MR urography.	O
MRI abdomen and pelvis without and with IV contrast	4	MR urography.	O
X-ray abdomen and pelvis (KUB)	3	This procedure can be performed with US as an alternative to NCCT.	##
CT abdomen and pelvis with IV contrast	2		####

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

***Relative Radiation Level**

A wide range of familial, environmental, dietary, and systemic factors are important factors in the genesis of lithiasis (1).

Stones are composed of
a combination of crystals (both inorganic and organic) and proteins.

Calcium-based stones

v Calcium oxalate monohydrate and dihydrate, and calcium phosphate stones ***account for 70%-80% of upper urinary tract stones***

v ***Struvite stones account for 5%-15%*** of stones and are composed of magnesium ammonium phosphate.

v Uric acid stones are unique in that they can often be dissolved with urinary alkalinization and account for ***5%-10% of stones*** and occur in acidic urine (pH <5.8)

v Other stones, including cystine, xanthine, and protein matrix stones, as well as drug (eg, triamterene, indinavir), ***account for less than 5% of stones***

Symptoms

v Stones impacted at the ureteropelvic junction produce **flank pain**;

v Stones lodged in the proximal ureter cause **flank pain radiating to the genitals** (2)

v Stones lodged at the ureterovesical junction **produce voiding urgency and suprapubic discomfort**, and they cause pain that radiates into the groin and genitals (3,4)

Associated symptoms include gross or microscopic hematuria, nausea, and vomit- ing.

Struvite stones often remain asymptomatic without causing obstruction (4,5).

Physical examination findings

v Nonspecific

v Main focus---- to rule out other abdominal conditions mimicking urolithiasis (3,4,5,6).

A complete blood count and urinalysis:

v Performed to rule out infection;

v Serum levels (eg, of electrolytes, blood urea nitrogen, creatinine, calcium, phosphorus, and uric acid) are determined to identify the cause of urolithiasis.

Multidetector CT and dual-energy CT

v Demonstrate the superiority
of this modality over other imaging techniques in the management of urolithiasis

Multidetector CT

v Accurate diagnosis in patients with stone disease;

v Assessment of stone burden, composition, and fragility

Mandatory to define the appropriate treatment

Additional Value

v Follow-up after urologic intervention

Awareness mandatory of the radiation risks

Unenhanced CT in the emergency department

v Nearly 1/4 of all all CT examinations performed for the evaluation of acute abdominal pain (6).

v *Dalrymple et al (5*) found that nearly 55% of patients undergoing CT for the evaluation of acute flank pain did not have stone disease

v Furthermore, the identification of ureterolithiasis at imaging has been found to alter management in nearly 55%-60% of patients suspected of having acute renal colic on the basis of clinical features and laboratory findings (6,7).

Unenhanced helical CT has gained widespread acceptance as the initial investigation of choice for the evaluation of patients with suspected urinary tract calculi (7,8).

v Sensitivity (95%-98%)

v Specificity (96%-100%)

Diagnosis of urolithiasis

Main advantages:

v It can be performed rapidly

v Does not require the administration of contrast material

v **Highly sensitive for the detection of stones of all sizes**

v Allows the detection of other unsuspected extraurinary and urinary abnormalities

v An additional benefit of CT is its ability to reveal urinary abnormalities such as congenital abnormalities, infections, and neoplasms, whose diagnoses have a greater clinical relevance than does that of stone disease

Multidetector CT

High-resolution coronal reformatted images **allows more rapid and accurate detection of urinary stones** than do axial images alone (5,6).

The quantification of stone burden with volumetric techniques, made feasible by the near-isotropic resolution of multidetector CT, holds great promise as both a tool for surgical planning and a predictor of treatment response (7,8).

In addition, multidetector CT helps

v Assessment of stone fragility and composition

v Characterization of internal structure of stones (4,5)

Differentiation between calcium-based stones and uric acid stones

Previously achieved only with standard multidetector CT thinner (1-3-mm) reconstruction sections:

v Recommended for better detection and characterization of urinary calculi **particularly small stones** (13,56)

5-mm CT scans along with 3-mm coronal reformatted images

v Improve stone detection

v **Radiation dose benefits** (5,6,7)

Acquiring CT scans with a **section thickness greater than 5 mm or scanning at 10 mm** :

v Misses a lot of small urinary calculi

v Affects size and attenuation measurements due to partial volume averaging effect resulting in lower average values (9,10)

Images can be prospectively acquired at 5-mm collimation, and the near-isotropic data set obtained with scanners having 16 or more detector rows can then be reconstructed at a 1-3-mm section thickness to reduce errors in attenuation determination (8,9).

Intravenous contrast material administration

Not routinely required for the diagnosis of calculi at CT

In **selected cases**, however, contrast material administration may be useful :

v Differentiating distal ureteral stones from phleboliths or vascular calcifications (9)

v Incidental detection of tumor or other diseases on unenhanced scans, contrast material enhanced CT may be required (10,11)

v Ureteral strictures, duplicated system, or uretero-pelvic junction obstruction

Value of Coronal Reformatted Images

v Axial imaging data sets are frequently used in the detection of renal stones

v Coronal or sagittal reformatted images are used to supplement the axial scans in tracing the entire length of the ureter

v Identify the exact site of stone impaction, as well as in detecting small (1,2mm) stones at the renal poles

Because the urothelial system is coronally oriented, the detection of urinary stones is not only quicker but also improved with coronal reformatted images

Multidetector CT Signs

v Virtually all stones are visible at unenhanced CT, including those that are

v Even radiolucent stones, visible on conventional radiographs, such as uric acid, xanthine, and cystine stones (11)

Attenuation value (>200 HU) greater than that of the surrounding soft tissue, and

The only stones that are difficult to visualize at CT are pure matrix stones and stones made of pure (11,12).

v These stones have soft-tissue attenuation (15-30 HU) and are **likely to be missed at unenhanced CT** (12,13)

v Intravenous contrast material may be administered in equivocal circumstances, with the **stones being clearly depicted as filling defects in the contrast material** filled pelvicaliceal system or ureter on delayed phase images (12)

The most direct CT sign for ureterolithiasis

ü **Stone within the ureteral lumen**, with proximal ureteral dilatation and a normal distal caliber (11,13)

ü **Ureteral dilatation may be absent** in a small number of cases of ureterolithiasis.

Reports suggest that stones greater than 6 mm in diameter in the proximal ureter accompanied by more than five secondary signs of obstruction are more likely to necessitate intervention such as endoscopic removal or lithotripsy than are those with fewer secondary signs.

Extraurinary abdominal and pelvic calcifications such as phleboliths located in the expected course of the ureter on the symptomatic side may be mistaken for ureteral calculi.

The routine use of coronal reformatted images, which allow tracking of the ureteral course, usually permits **confident differentiation between calculi and other calcific processe**s.

ü Two signs, the "soft-tissue
rim sign" and the "comet tail sign," have been described for the differentiation of ureteral stones from these calcifications (14,15).

The soft-tissue rim sign

ü Consists of a **halo of soft-tissue attenuation** around a calcific focus and is very specific for ureteral calculi rather than phleboliths (15,16)

ü The soft-tissue rim represents the **edematous wall of the ureter** around the calculus and has a sensitivity of 50%-77% and a specificity of 90%-100% (17)

ü The **presence or absence of the rim is found to correlate with the size of the calculus** rather than the degree of obstruction (17,18)

The comet tail sign

ü Eccentric, tapering soft-tissue area adjacent to the calcification

Stone Burden

ü One of the most important factors in determining treatment strategies and management in cases of urolithiasis (19)

ü The simplest and most common method of assessing stone burden is measurement of stone size

Stone Fragility

CT can be used to visualize the internal structure of stones, which is best appreciated when viewed with **bone window settings** and when imaged at high resolution with thin sections (17).

At CT, the internal structure can be considered to be either heterogeneous or homogenerous:

ü Heterogeneous stones are characterized by the presence of internal low-attenuation areas (voids or dark areas)

ü Homogeneous stones have a uniform internal structure

Stone Composition

One of the key determinants of appropriate management in patients with urinary calculi is the knowledge of stone composition:

ü Uric acid stones may be treated with **urinary alkalinization** as a first-line treatment, with surgical treatment being reserved for stones that do not respond to medical therapy

ü Stones of certain compositions (eg, cystine stones), as well as calcium-based stones of certain attenuation, **are extremely difficult to fragment with Shock wave lithotripsy (SWL)** (17,18,19)

B

The attenuation values of urinary calculi at 120 kV usually fall within certain ranges:

Uric acid	200-450 HU
Struvite	600-900 HU
Cystine	600-1100 HU
Calcium phosphate	1200-1600 HU
Calcium oxalate monohydrate and brushite	1700-2800 HU

(20,21,22)

Attenuation measurement

Becomes more complicated in stones of mixed composition (35%-65% of stones) (1,16,17).

Because stones of mixed composition, as well as struvite, cystine, and calcareous stones

ü Overlapping attenuation ranges in vivo

ü CT attenuation measurements have been most valuable in allowing differentiation of 100% uric acid stones from other stones (20).

Primary Findings

Primary findings of a calculus include **direct visualization of the calculus within the urinary tract.**

Hindered passage of a calculus commonly occurs in areas of luminal narrowing secondary to a change in course, narrowed caliber, or extrinsic impression.

Typical locations

ü The uretero- pelvic junction

ü The level of ureteral passage over the pelvic brim

ü Ureterovesical junction are typical such locations

Scanning in the prone position may be useful to **distinguish a calculus impacted at the ureterovesical junction and a stone that has already passed into the bladder** [2].

Secondary Findings

Include imaging signs of obstruction or infection. Early or subtle obstruction may manifest as loss of the normally hyperdense medullary pyramid on unenhanced CT [9]. **This sign reflects focal edema.**

Asymmetric renal enlargement may also be present on the affected side:

ü Early renal enlargement may be more focal at the renal poles (4,5). Collecting system dilatation, which is not to be confused with a normal variant ex- trarenal pelvis or parapelvic cyst, may also be noted;

ü Collecting system dilatation will obliterate renal sinus fat;

ü An extrarenal pelvis or a parapelvic cyst will coexist with normal fat (10).

Common findings with ureteral calculus (11)

ü Hydronephrosis (69%)

ü Perinephric edema (65%)

ü Periureteral edema (65%)

The ***"twinkling artifact",*** also called "color comet-tail artifact" is visible on Color Doppler Ultrasound (US) examinations as a rapid alternation of color immediately behind a stationary echogenic object, acquiring a false appearance of movement.

It may also manifest when power Doppler and Spectral Doppler scannings are performed, appearing as a sign of heterogeneous spectral expansion composed of adjacent vertical lines with no waveform at all(1,2).

Twinkling artifact

Meaning

Nature of the scintillation remains poorly understood. The presence of a narrow-band noise due to fluctuations in the circuits of Doppler ultrasound equipment has been proposed as the underlying cause of this sign (1). It is mainly observed on rough,

The twinkling artifact can be detected in calcified areas of various tissues, thus representing a remarkably useful tool in the diagnosis and monitoring of diverse clinical entities(4).

Images for this section:

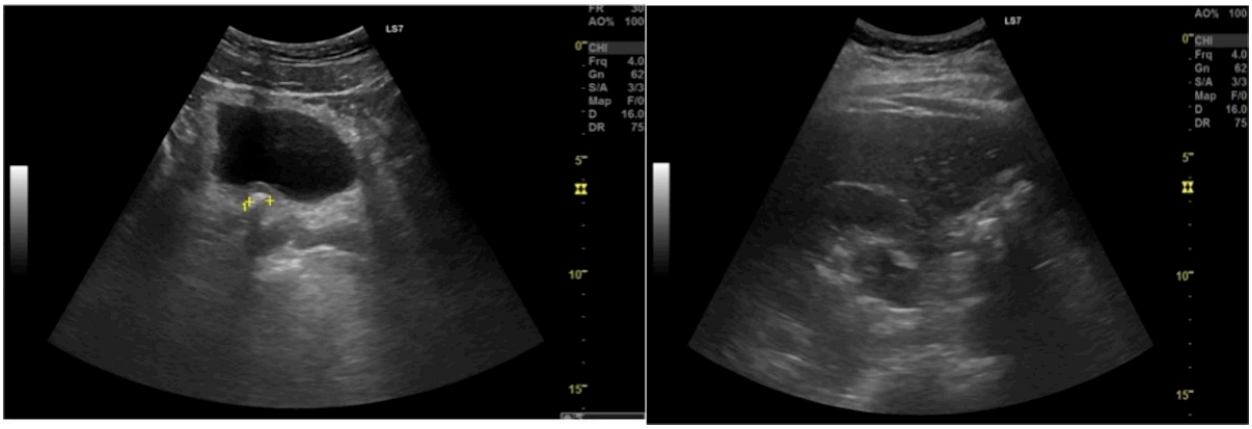

Fig. 2: Lithiasis foci in the distal ureter causing upstream dilation

Fig. 3: Lithiasis foci in the distal ureter with inflamed ureter and densification of the involving tissues

Fig. 4: Lithiasis foci in the distal ureter

Fig. 5: Lithiasis foci in the uretero-pelvic junction causing marked dilation

Conclusion

Knowledge and systematic approach facilitates decision making and lowers error probability of the YR facing UL

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