# La calcolosi urinaria :patologia di interesse multidisciplinare

Nuovi standard radiologici e di medicina nucleare nello studio della litiasi urinaria

CT

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I MARTEDI DELL' ORDINE
PARMA 1 MARZO 2016

# Imaging of urinary calculi

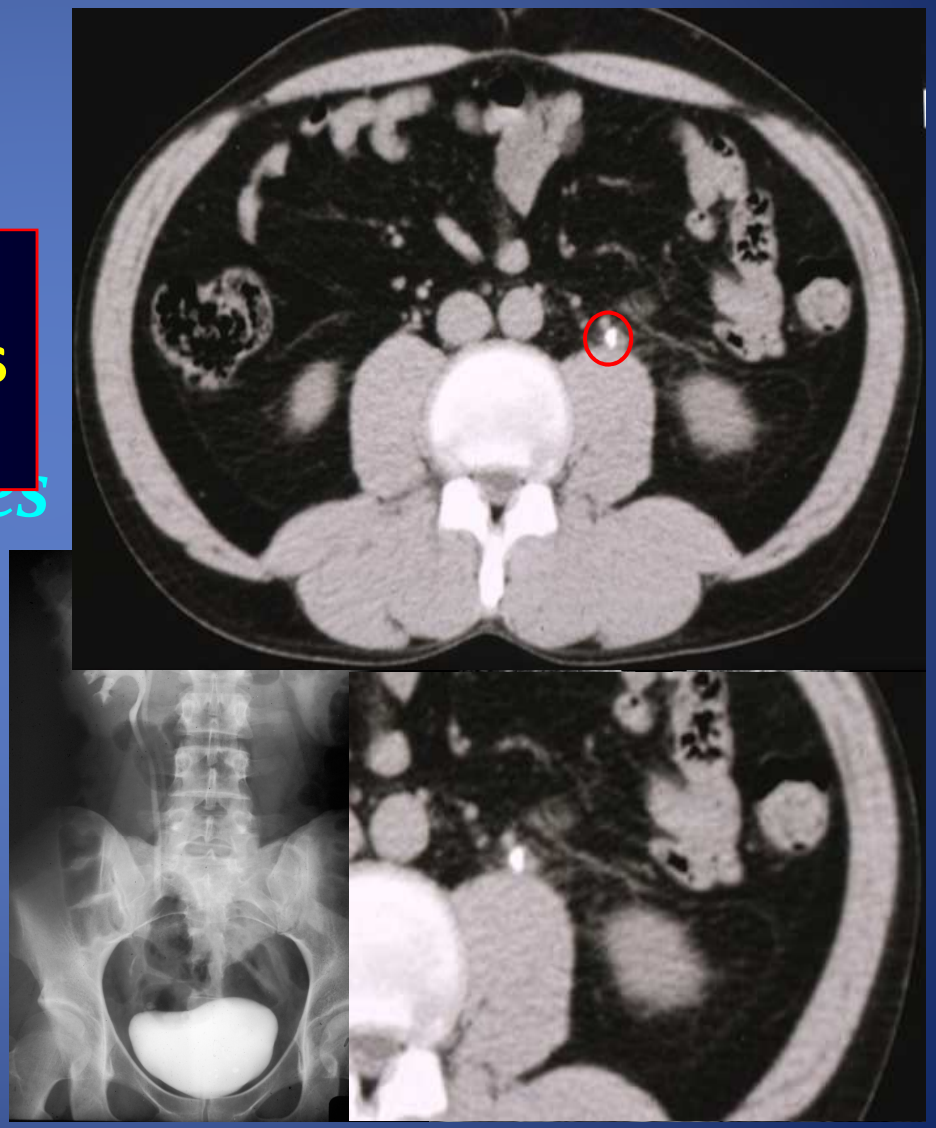
## Diagnostic protocols:

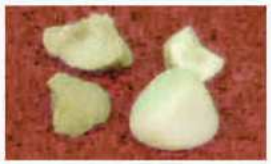
- ✓ **KUB + US**
  *Hill, AJR 1984*

**The new gold standard for imaging urinary stones**

- ✓ **IVU *in unsolved cases***
  *Dalla Palma L, Clin Radiol 1993*

- ✓ **Unenhanced CT (UHCT)**
  *Smith RC, Radiology 1995*



| | Composition | Frequency of Occurrence | KUB Radiographic Appearance | CT Appearance/Attenuation (HU) | Associated Etiologic Factors |
|---|---|---|---|---|---|
|  | Calcium oxalate monohydrate and dihydrate (calcium oxalate dihydrate) | 40%–60% | Radiopaque | Opacified/ 1700–2800 | Underlying metabolic disorder (eg, idiopathic hypercalcuria or hyperoxaluria) |
|  | Hydroxyapatite (calcium phosphate) | 20%–60% | Radiopaque | Opacified/ 1200–1600 | Usually no metabolic abnormality |
|  | Brushite | 2%–4% | Radiopaque | Opacified/ 1700–2800 | . . . |
|  | Uric acid | 5%–10% | Radiolucent | Opacified/ 200–450 | Idiopathic hyperuricemia or hyperuricosuria |
|  | Struvite | 5%–15% | Radiopaque | Opacified/ 600–900 | Renal infection |
|  | Cystine | 1%–2.5% | Mildly opaque | Opacified/ 600–1100 | Renal tubular defect |

# UHCT Advantages

- It can be performed rapidly.
- It doesn’ t require administration of contrast media .
- It’ s highly sensitive for the detection of stones of all sizes.
- Informations about stone composition.
- It allows detection of other unsuspected extraurinary and urinary abnormalities.

# UHCT Technique

- Tailored to the indications.
- Moderate bladder distention.
- Thinner reconstruction sections (1-3 mm.)
- Multiplanar reconstruction ( coronal and sagittal) are very useful to improve detection of small stones at renal poles and facilitate differentiation of phleboliths.

# Imaging of urinary calculi

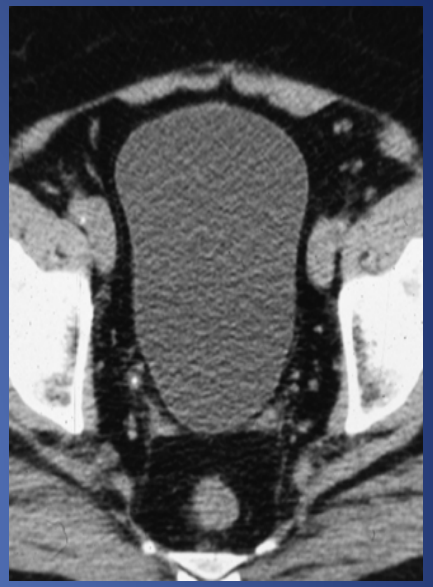
## UHCT

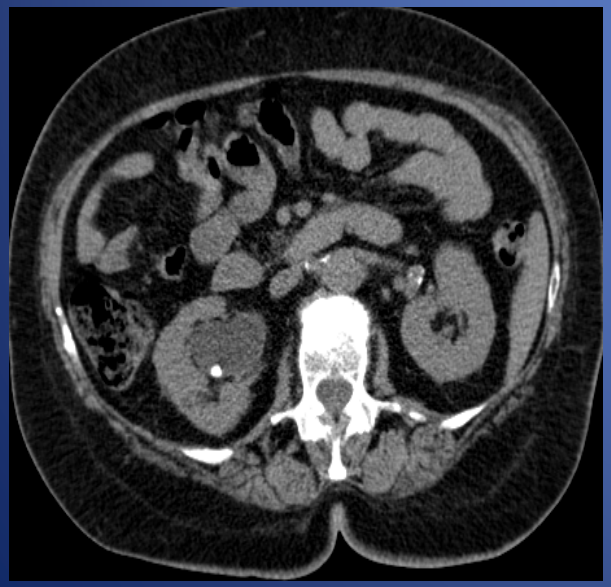
### Direct sign: identification of the stone

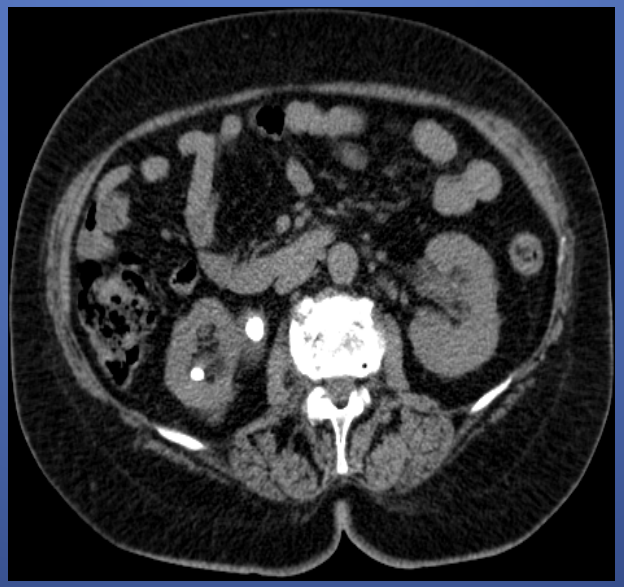
**Sensitivity: 95%-98%**

**Specificity: 96%-100%**

*Smith RC, AJR 1996*
*Fielding JR, J Urol 1997*
*Chen MYM, J Emerg Med 1999*
*Niall O, J Urol 1999*







# Imaging of urinary calculi

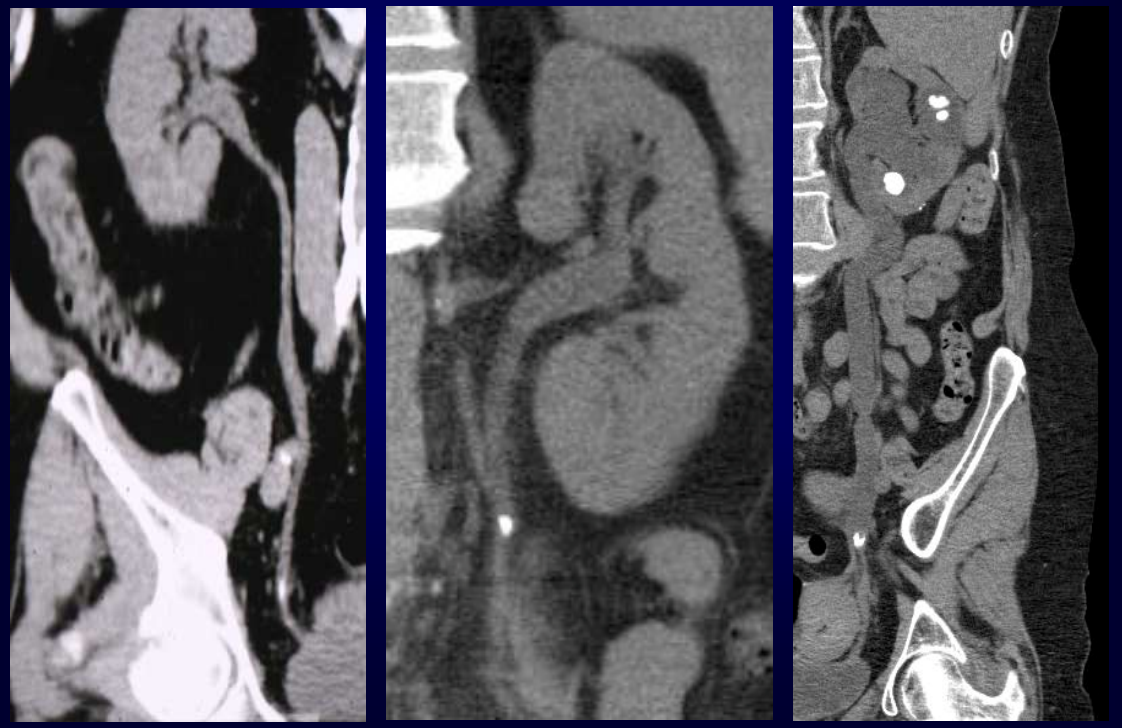
## UHCT

### Secondary signs

- ✓ Ureteral dilatation

**Frequency**

| | |
|---|---|
| *SMITH et al. (1996)* | *90%* |
| *KATZ et al. (1996)* | *67%* |
| *YILMAZ et al. (1998)* | *84%* |
| *NIALL et al. (1999)* | *96%* |
| *SOURTZIS et al. (1999)* | *64%* |

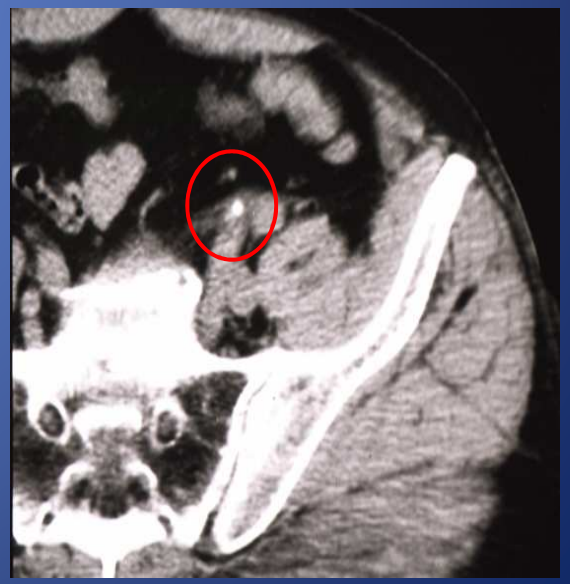


# Imaging of urinary calculi

## UHCT

### Secondary signs

- ✓ *Ureteral dilatation*
- ✓ Perinephric and periureteral stranding

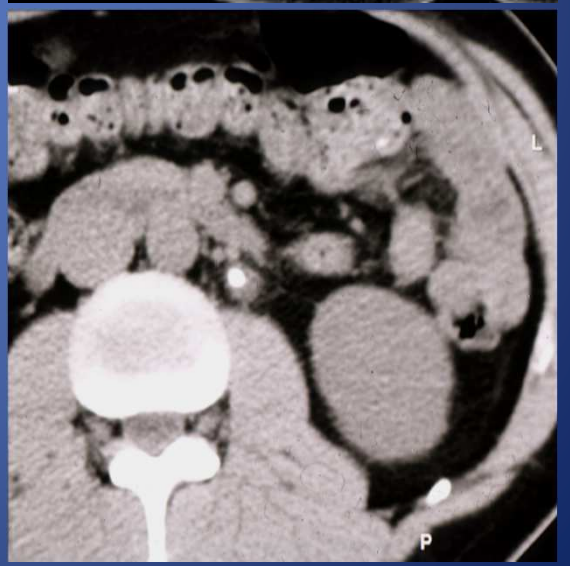
| | | |
|---|---|---|
| **Frequency** | *SMITH et al. (1996)* | *82%* |
| | *KATZ et al. (1996)* | *65%* |
| | *YILMAZ et al. (1998)* | *70%* |
| | *NIALL et al. (1999)* | *71%* |
| | *SOURTZIS et al. (1999)* | *36%* |

# Imaging of urinary calculi

## UHCT

### Secondary signs

- ✓ *Ureteral dilatation*
- ✓ *Perinephric and periureteral stranding*
- ✓ Rim sign



| Frequency | | |
|---|---|---|
| | *SMITH et al. (1996)* | *69%* |
| | *HENEGHAN et al. (1997)* | *77%* |
| | *KAWASHIMA et al. (1997)* | *50%* |
| | *NIALL et al. (1999)* | *64%* |
| | *SOURTZIS et al. (1999)* | *75%* |

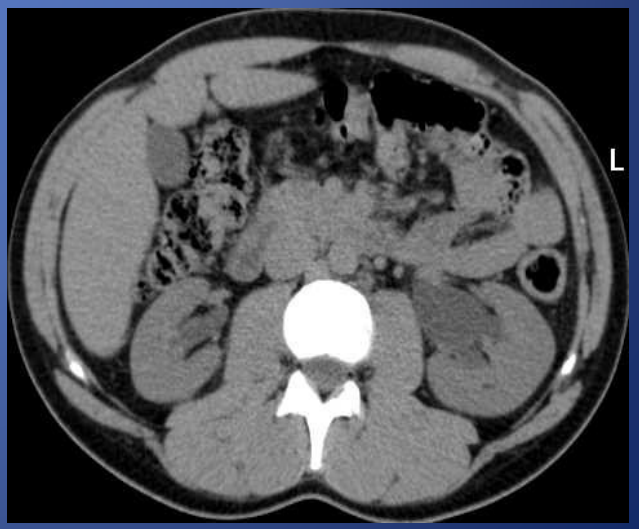
# Imaging of urinary calculi

## UHCT

### Secondary signs

- ✓ *Ureteral dilatation*
- ✓ *Perinephric and periureteral stranding*
- ✓ *Rim sign*
- ✓ **Renal enlargement**

| | | |
|---|---|---|
| **Frequency** | *SMITH et al. (1996)* | *71%* |
| | *YILMAZ et al. (1998)* | *53%* |
| | *NIALL et al. (1999)* | *36%* |



# Imaging of urinary calculi

## UHCT

### Secondary signs

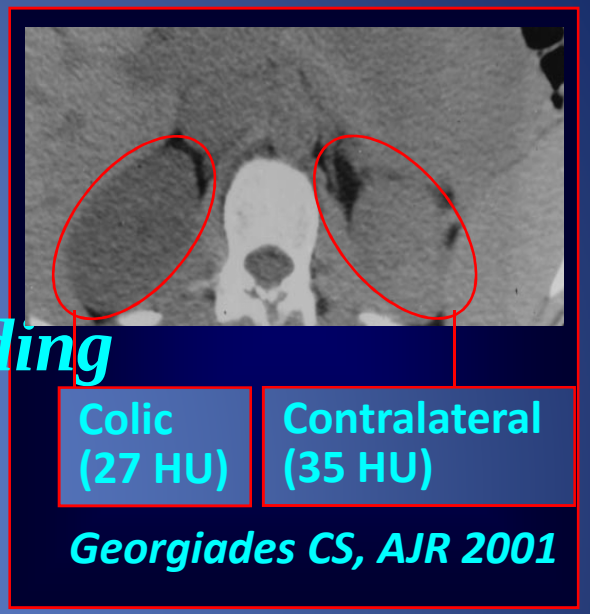
- ✓ *Ureteral dilatation*
- ✓ *Perinephric and periureteral stranding*
- ✓ *Rim sign*
- ✓ *Renal enlargement*
- ✓ **Renal sinus fat blurring**

# Imaging of urinary calculi

## UHCT

### Secondary signs

- ✓ *Ureteral dilatation*
- ✓ *Perinephric and periureteral stranding*
- ✓ *Rim sign*
- ✓ *Renal enlargement*
- ✓ *Renal sinus fat blurring*
- ✓ *Thickening of lateroconal fascia*
- ✓ **Reduced attenuation (>5HU) of the of the renal parenchyma**




*Georgiades CS, AJR 2001*
*Goldman SM, AJR 2004*

***Not specific for acute obstruction; may also be caused by interstitial edema from acute pyelonephritis and by venous congestion from renal vein thrombosis***

# Imaging of urinary calculi

## UHCT

### Pitfalls and limitations

"A major pitfall in the interpretation of UHCT in the evaluation of patients with suspected ureterolithiasis is the frequent inability to identify accurately the ureter amongst periureteral vessels and to differentiate with certainty ureteral stones from extraurinary calcifications"

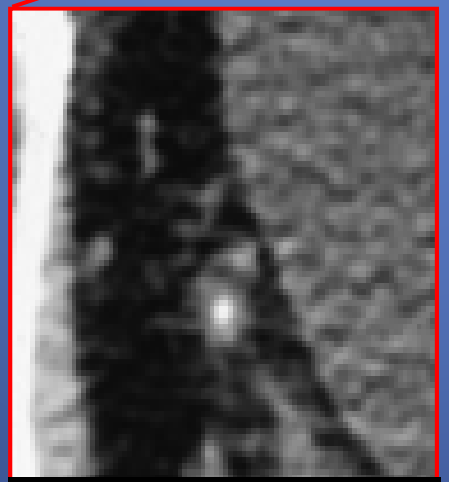
*Hartman RP et al., Helical CT in the diagnosis of urolithiasis. In: Morcos SK, Cohan, RH. New Techniques in Uroradiology, Taylor & Francis, NY, 2006*

# Imaging of urinary calculi

## UHCT

**Differential diagnosis between urinary stones and extraurinary calcifications**

- ✓ **Rim sign is specific for urinary stone**
  **sensitivity 50-77% specificity 90-100%**



*Rim sign*

# Imaging of urinary calculi

## UHCT

**Differential diagnosis between urinary stones and extraurinary calcifications**

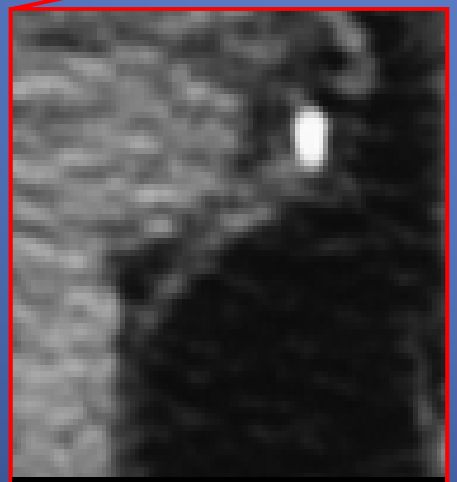
- ✓ *Rim sign is specific for urinary stone*
- ✓ **The "comet tail" sign is a useful sign in diagnosing phleboliths**

*Bell TV, Radiology 1998*
*Boriady IC, Radiology 1999*

*Eccentric tapering of soft tissue extending from one surface of the calcification*

*The comet tail sign does not preclude a coexisting ipsilateral calculus*

*Guest AR, AJR 2001*



*Comet tail sign*

# Imaging of urinary calculi

## UHCT

**Differential diagnosis between urinary stones and extraurinary calcifications**

- ✓ *Rim sign is specific for urinary stone*
- ✓ *The "comet tail" sign is a useful sign in diagnosing phleboliths*
- ✓ Most phleboliths are round or oval, most ureteral calculi are slightly angular in shape

*Traubici J, AJR 1999*

# Imaging of urinary calculi

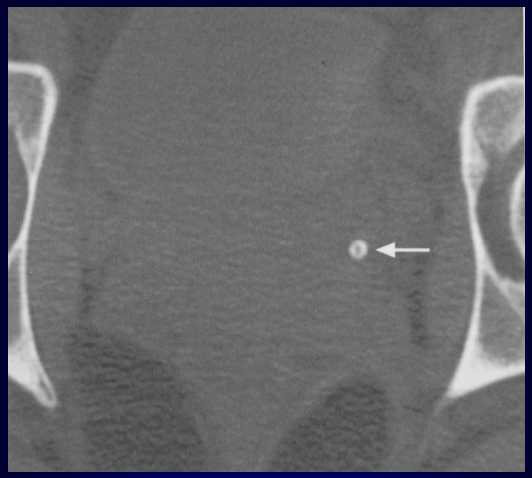
## UHCT

**Differential diagnosis between urinary stones and extraurinary calcifications**

- ✓ *Rim sign is specific for urinary stone*
- ✓ *The "comet tail" sign is a useful sign in diagnosing phleboliths*
- ✓ *Most phleboliths are round or oval, most ureteral calculi are slightly angular in shape*
- ✓ Phleboliths may contain a central lucent area

***Rarely seen at CT!***

*Traubici J, AJR 1999*



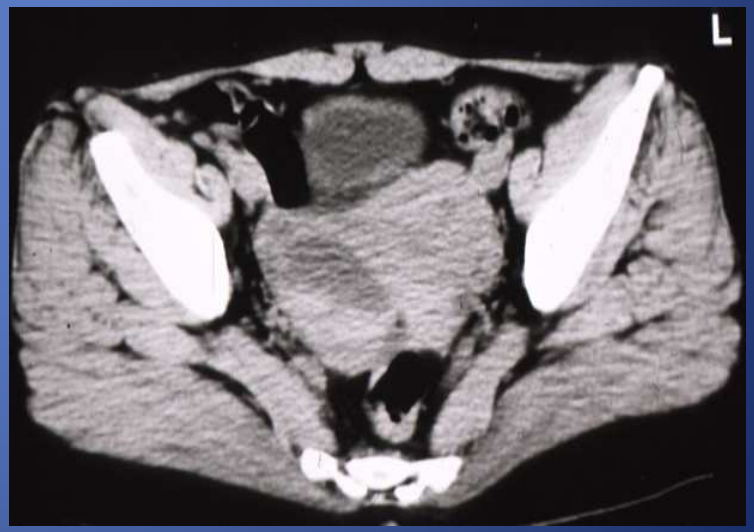
*Hartman RP et al., In: Morcos SK, Cohan, RH. New Techniques in Uroradiology, Taylor & Francis, NY, 2006*

# Imaging of urinary calculi

## CE-CT

- ✓ *Differentiation of stones from phleboliths*
- ✓ *Differentiation of parapelvic cysts from hydronephrosis*
- ✓ *Clinically suspected complicated pyelonephritis*
- ✓ *Useful in conditions such as ureteral strictures, duplicated system or ureteropelvic junction obstructions.*
- ✓ Evaluation of alternative causes of flank pain
  - ➢ *Diverticulitis, appendicitis*
  - ➢ *Pelvic masses*
  - ➢ *Large renal tumors*
  - ➢ *Bowel obstruction*
  - ➢ *Aortic aneurysm*
  - ➢ *….*

**Most of them are identified at UHCT**

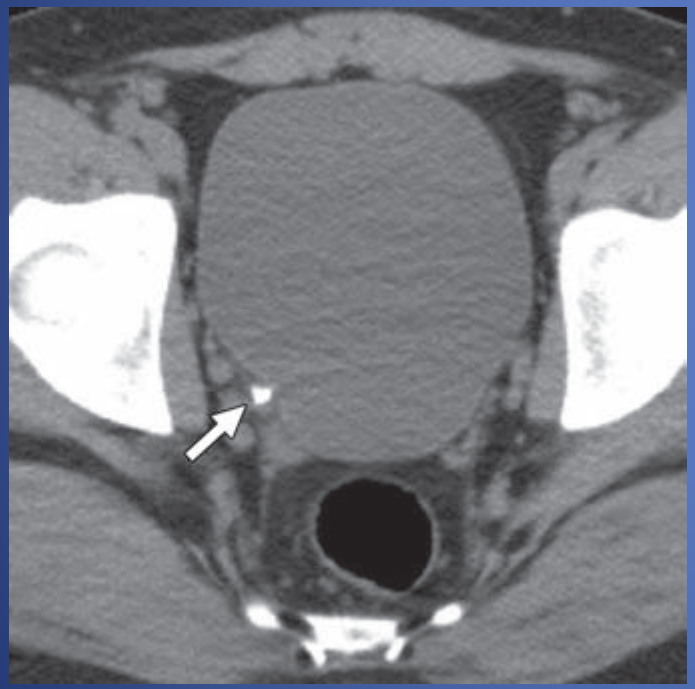


# Stone evaluation

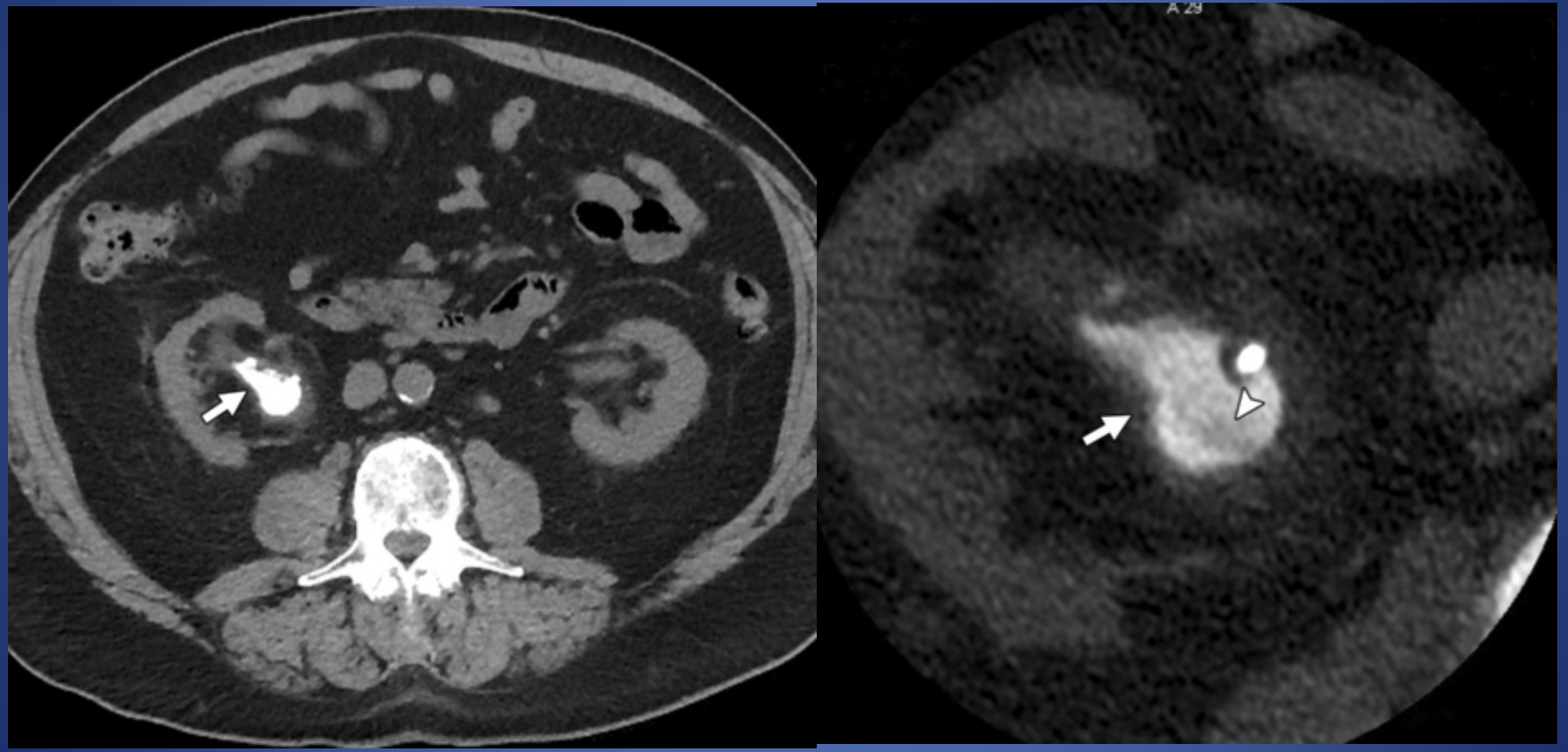
- Stone burden ( size evaluation better with bone windows).
- Stone fragility ( heterogeneous or homogeneous).
- Stone composition.
- Treatment planning.
- Posttreatment evaluation.

# Stone burden

- Number
- Size ( at least 2 planes better  with bone- window)
- Location

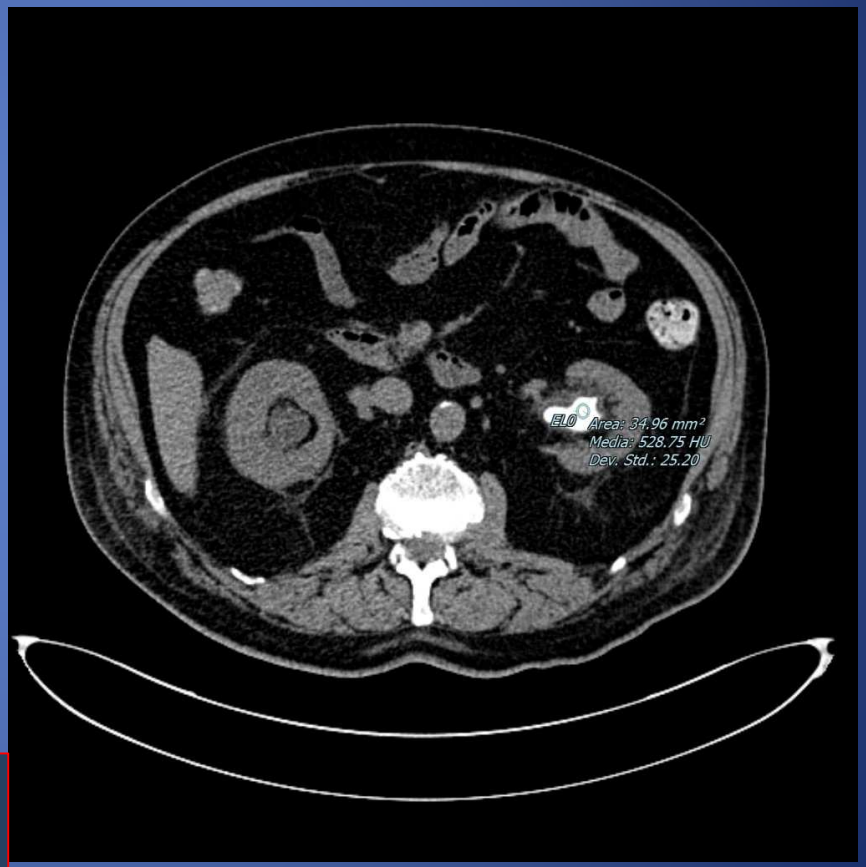


# Stone fragility



# Stone composition

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




Stones of mixed compostion have overlapping attenuation ranges in vivo. CT attenuation measurements have been most valuable in differentiation of 100% uric acid stones from other stones .

Dual-Energy CT ?

# Treatment planning

- Multidetector CT not only assists in the selection of an appropriate calix for percutaneous access, but it also helps ascertain a safe path for puncture by depicting the relationship of the kidney to various surrounding organs such as the spleen, liver, and colon.
- Evaluation of SSD.
- Evaluation of infundible-pelvic angle.

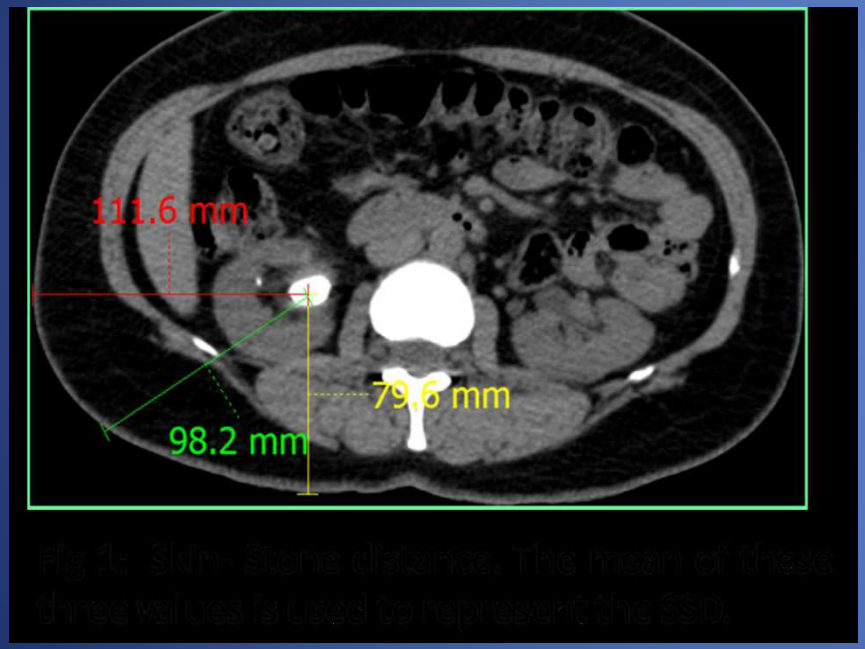
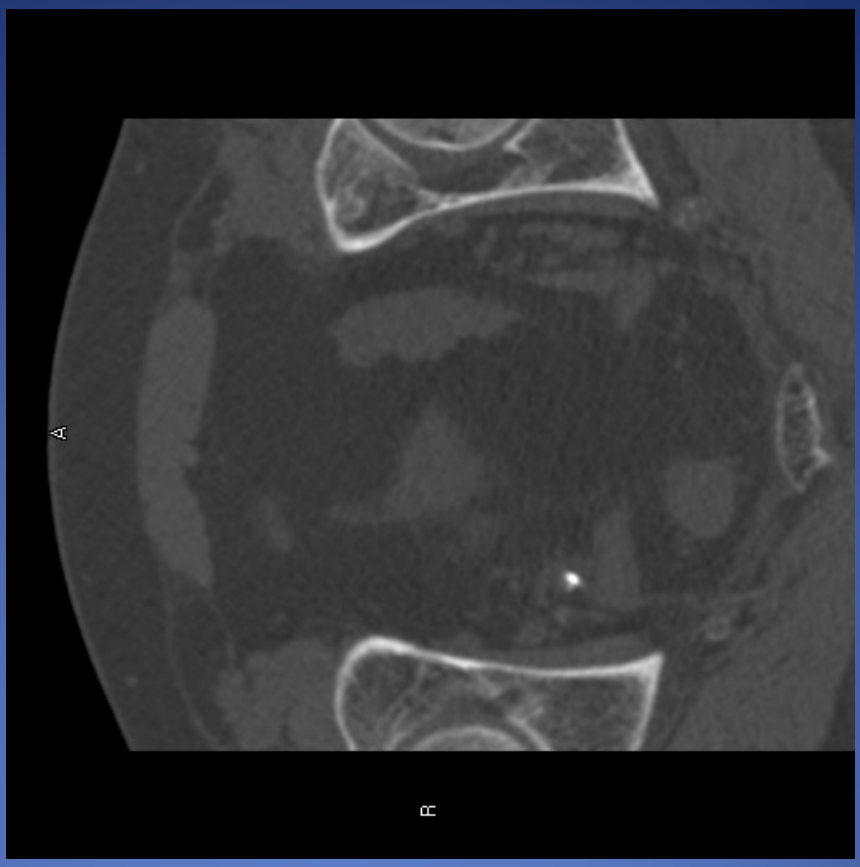
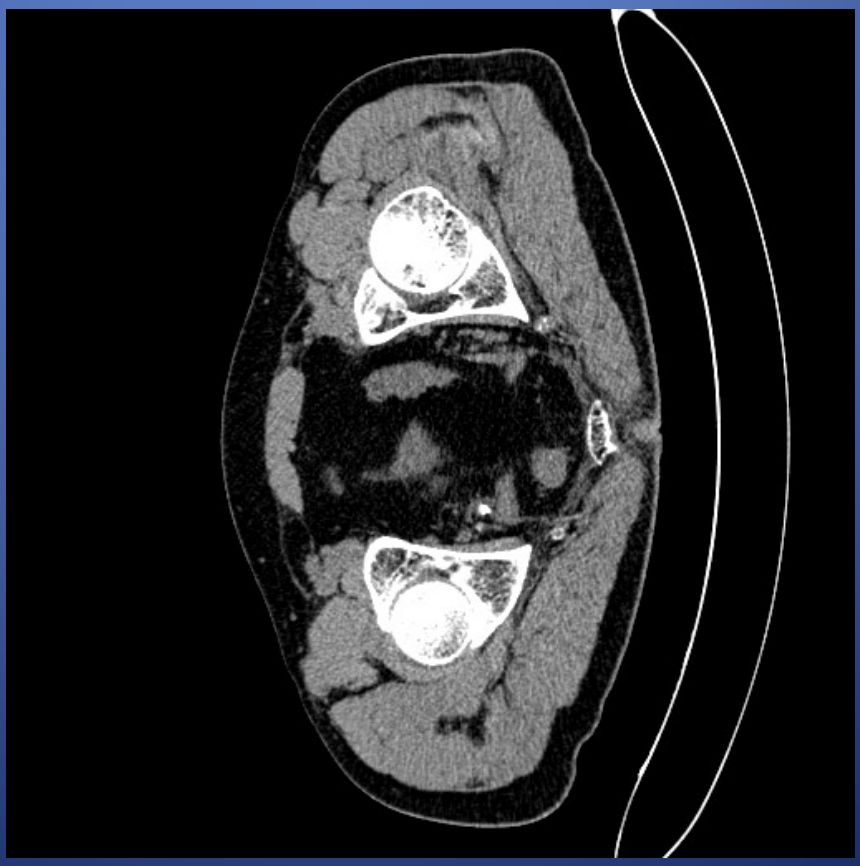


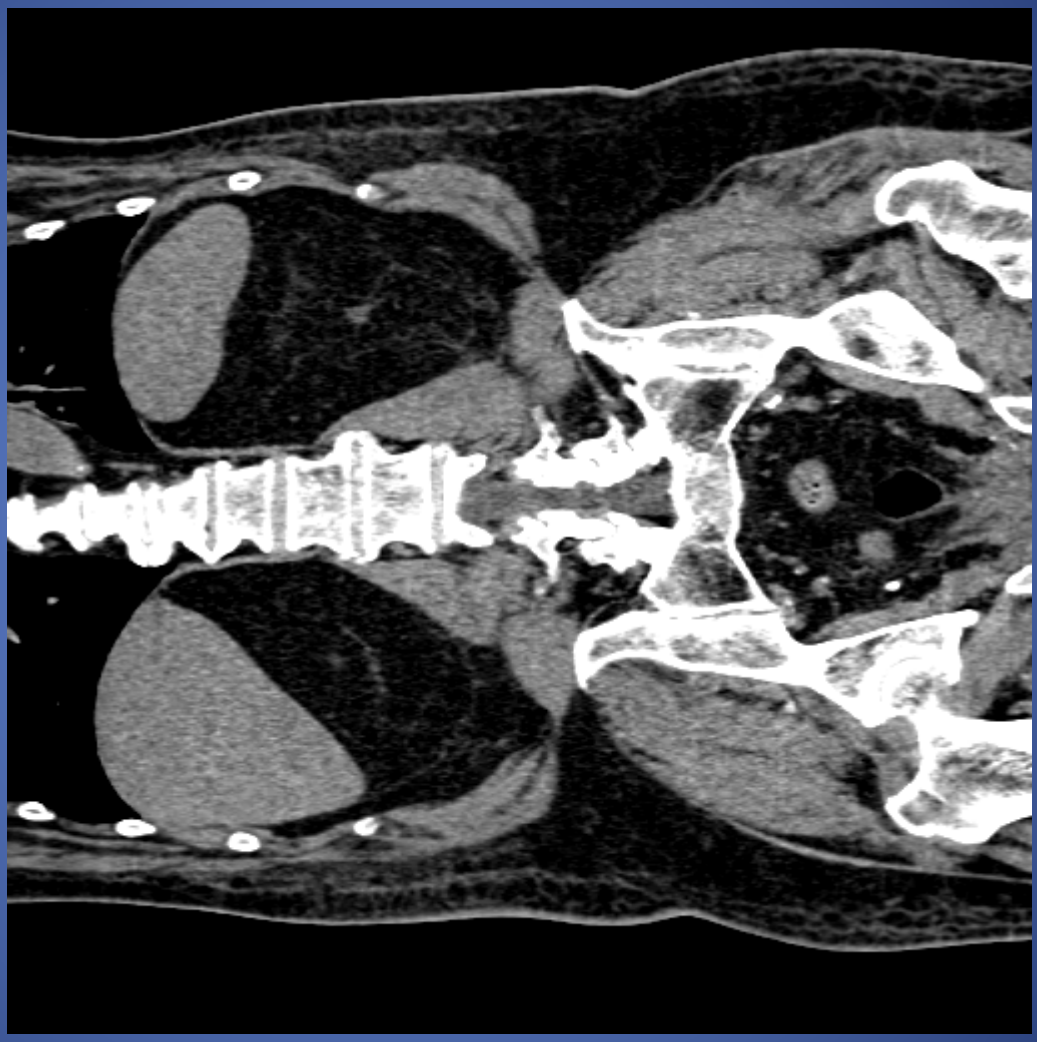

Fig 1: Skin- Stone distance. The mean of these three values is used to represent the SSD.

# Posttreatment Evaluation

- Confirm stone-free status .
- Identify the presence of residual stones.
- Rule out obstruction in the urinary system .
- Detection of complications such as perirenal hematoma and urinoma ( CECT) .







# Imaging of urinary calculi

## UHCT

**The gold standard**
**for imaging patients with urinary calculi**
**…..but radiation dose is a significant problem**

**Radiation exposure of regular-dose CT**

| | | mSv |
|---|---|---|
| *Ruppert-Kohlmayr et al, 1999* | | 4.3 |
| *Becker et al, 19* | | |
| *Cohnen et al, 2* | | |

**of different modalities**

| | | mSv |
|---|---|---|
| | | 0.69 |
| | | 0.5-0.9 |
| | | 1.5 |
| *IVU* | *Liu et al, 2000* | 1.33 |
| *IVU* | *Thomson et al, 2001* | 3.5 |

- ✓ **Most stones have chance to pass spontaneously**
- ✓ **Young patients at significant life time risk for recurrent renal colics**

Chest X –ray : 0,02 mSv.

# Imaging of urinary calculi

## UHCT

The new gold standard
for imaging patients with renal colic
**…..but radiation dose is a significant problem**

Developement of low dose
and ultra low-dose CT
protocols

is
0.05% (1 in 2,000) for 10 mSv of ionizing radiation
[5, 17]. This estimate is determined by linear extrapolation from the risk of 5% per each sievert established by the International Commission on Radiological Protection in

| Method | Radiation exposure (mSv) |
|---|---|
| KUB radiography | 0.5-1 |
| IVU | 1.3-3.5 |
| Regular-dose NCCT | 4.5-5 |
| Low-dose NCCT | |
| Enhanced CT | |

Rx torace : 0,02 mSv.

# Strategies for dose reduction

- Appropriate patients selection.
- Limiting the scan range.
- Using  automatic tube current modulation such as “ care dose”.
- Weight based selection of tube voltage.

# UHCT in all cases?

- Nearly 55 % of patients undergoing CT for evaluation of acute flank pain did not have stone disease .
- 15 % had other abnormalities.
- Stones  5 mm of less in diameter had a spontaneous passage rate of 68 %, stones greater than 5 mm but less than or equal to 10 mm. had a spontaneous passage rate of 47 %.
- Young patients , high life time recurrence of renal colic.

NO

# Imaging of urinary calculi

## Is UHTC needed in all patients with renal colic?

*UHCT is the best imaging procedure for evaluation of patients with renal colic…*

***… But US will provide enough clinically useful information in most cases without radiation***

**High end US equipment, <u>appropriate training</u> to improve operator's skill**

- ✓ **Identifies hydronephrosis**
- ✓ **Detection of ureteral stones can improve**
- ✓ **Identifies clinically significant extraurinary pathologies**

# Suggesting CT reporting points for urolithiasis

## What the Radiologist Needs to Know About Urolithiasis: Part 2—CT Findings, Reporting, and Treatment

*AJR* 2012; 198:W548–W554

| Criterion | Key Points |
|---|---|
| Number | Multiple pyramidal calculi can indicate medullary sponge kidney |
| Size | Largest dimension in axial and coronal planes using magnified bone windows |
| Anatomic localization | Possible locations (subdivisions): kidney (upper pole, mid, or lower pole), ureteropelvic junction, ureter (proximal, mid, or distal), ureterovesical junction, bladder, and urethra |
| Associated findings | Identify and assess degree (mild, moderate, or severe), obstruction (e.g., loss of hyperdense medullary pyramid, asymmetric renal enlargement, collecting system or ureteral dilatation, perinephric or periureteral edema or stranding), and infection (e.g., perinephric or periureteral edema or stranding and focal fluid collection) |
| Procedurally relevant anatomy | Relationship of kidney to surrounding organs (e.g., bowel, vessels, pleural reflections, and diaphragm); complex or variant anatomy (e.g., single kidney, transplant kidney, pelvic kidney, horseshoe kidney, crossed fused renal ectopia, abnormal infundibular orientation, and partial or complete collecting system duplication) |
| Non-calculus-related abnormalities | Genitourinary mass and nongenitourinary abnormalities (e.g., other potential causes of pain, such as appendicitis or diverticulitis, and vascular calcifications) |

# TAKE HOME POINTS

- Correct indication.
- Adeguate technique.
- Post-processing.
- Dose reduction.

STRUCTURED CT REPORT
TEMPLATE FOR UROLITHIASIS

DEMOGRAPHIC DETAILS:

Name:_____ Age:_____ Sex:_____

Date of Examination:_____

Indication for CT study:_____

Prior comparison CTs:_____

FINDINGS:
Stones present: Y / N
Number of stones:_____

Location:
1. Side: L / R
2. Kidney: Upper pole / Mid pole / Lower pole / Renal pelvis / Staghorn
3. Ureteropelvic junction
4. Ureter: Proximal (i.e. above sacroiliac vessels), distal (i.e. below sacroiliac vessels), ureterovesical junction
5. Bladder

Size (mm):___ Volume (cc):___ Density (HU):___

Internal structure: Homogeneous / Heterogeneous

Stone to skin distance (cm):____

Secondary signs:
a) Hydronephrosis / Hydroureter
b) Perinephric stranding
c) Periureteral stranding
d) Delayed renal excretion

Radiation dose:_____

Impression:_____

**Figure 4.** Structured radiology report template for assessment of urolithiasis with multidetector CT.

# La calcolosi urinaria :patologia di interesse multidisciplinare

Nuovi standard radiologici e di medicina nucleare nello studio della litiasi urinaria

CT

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