



Beth Israel Deaconess
Medical Center



HARVARD MEDICAL SCHOOL
TEACHING HOSPITAL

CASE PRESENTATION

BETH ISRAEL DEACONESS MEDICAL CENTER RADIOLOGY CLERKSHIP
AUGUST 2016

ACHYUT PATIL, MS3
GILLIAN LIEBERMAN, MD

RADIOLOGIC ASSESSMENT OF UROLITHIASIS AND URETERAL TRAUMA

OUTLINE

- Overview of ureteral anatomy and urolithiasis
- Radiologic considerations in diagnosis and treatment of urolithiasis
 - ACR appropriateness criteria
 - Comparison of imaging options for urolithiasis
- Complications of lithotripsy as treatment for urolithiasis
 - ACR appropriateness criteria
 - Comparison of imaging options for ureteral/renal trauma
- Overview of role of imaging in decision-making

URETERAL ANATOMY

- Abdominal Ureter (retroperitoneal)
 - Origin at renal pelvis
 - Courses posterior to renal artery/veins
 - Runs inferiorly along medial psoas
 - Runs anteromedially to L2-L5 transverse processes
- Pelvic Ureter
 - Medial to sacroiliac joint
 - Crosses over the common iliac artery at bifurcation
 - Crosses *under* the vas deferens (m) and ovarian/uterine arteries (f)
 - Moves laterally toward ischial spine
 - Inserts distally at base of bladder



*IV pyelogram demonstrating normal ureteral course.
[Reisner et al]*

URETERAL ANATOMY

- Proximal origin: UPJ (ureteropelvic junction)
- Distal insertion: UVJ (ureterovesicular junction)



CT Urogram, excretory phase, demonstrating normal ureteral anatomy [Potenta et al]

Potentia S, D'Agostino R, Sternberg K, Tatsumi K, Perusse K. CT Urography for Evaluation of the Ureter. Radiographics 2015;35:709-726.

UROLITHIASIS

- Formation/presence of solid stone deposit within urinary tract
- Make-up:
 - 80%: Calcium (calcium oxalate > calcium phosphate)
 - 20%: Other
 - Struvite (triple phosphate, AMP)
 - Uric Acid
 - Cystine
 - Xanthine



Bilateral non-obstructing calculi on CT (axial, non-contrast). Case courtesy of Dr Jeremy Jones, Radiopaedia.org, rID: 6211

INDEX CASE

- CC: 53 year-old male with gross hematuria.
- HPI: 1 x self-limited hematuria at beginning of urinary stream.
- ROS: Denies flank pain, clots in urine, dysuria.
- PMH: Hypertension, renal calculi.
- FHx: No history of renal or urologic abnormality.
- SHx: No smoking history. No travel to Schistosomal endemic areas.
- Exam: external genitalia within normal limits. Prostate [2]+, smooth, no nodules

Next step: radiologic assessment



ACR APPROPRIATENESS CRITERIA

HEMATURIA: For all patients except those with vigorous exercise, infection, present/recent menstruation, renal parenchymal disease

PROCEDURE	RATING	COMMENTS	RRL
CTAP with and without IV contrast	9	CT Urography. Need high-resolution imaging during excretory phase.	4
CTAP without IV contrast	6		4
X-ray retrograde pyelography	6	<i>If IV contrast contraindicated or suspected urothelial lesion.</i>	3
CTAP with IV contrast	5		4
US kidney/bladder, retroperitoneal	5		0
MRI AP with and without IV contrast	5	<i>MR Urography. If IV contrast contraindicated.</i>	0
MRI AP without IV contrast	4		0
Arteriography kidney	2		3
X-ray AP (KUB)	2		2
X-ray IV urography	1		3

AP = Abdomen and Pelvis. RRL = Relative Radiation Level

Shen L, Raman S, Beland M, et al. ACR Appropriateness Criteria® Hematuria.
 Available at <https://acsearch.acr.org/docs/69490/Narrative>. American College of Radiology.
 Accessed August 16, 2016..

SELECTING A RADIOLOGIC APPROACH

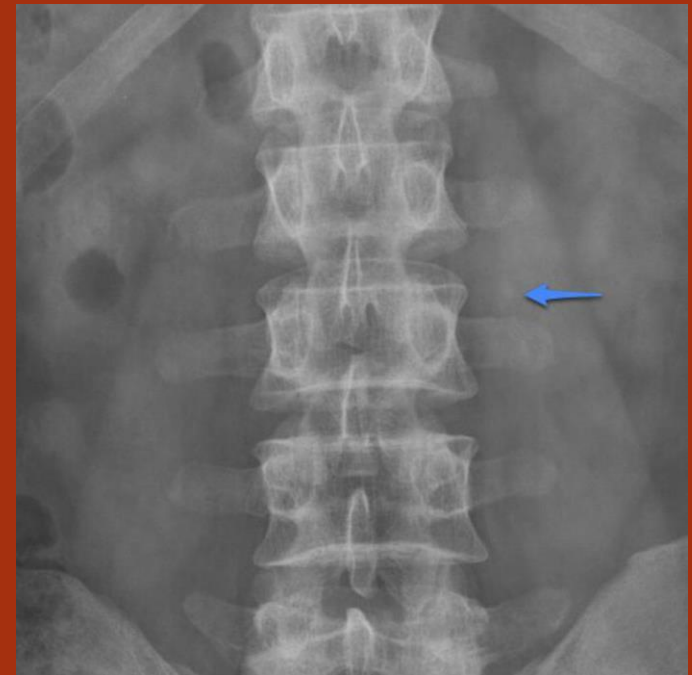
KUB (Abdominal Plain Film Radiograph)

➤ Advantages

- Fast
- Inexpensive
- Historically used to identify renal/ureteral calculi
- Calcium/AMP stones opaque
- Cystine/calcified uric acid semiopaque

➤ Disadvantages

- Xanthine, matrix, and uric acid calculi radiolucent
- Ureter is not directly visualized
- Differential diagnosis: pelvic phlebolith



KUB demonstrating radiopacity above L3 transverse process

Not routinely used to work up hematuria. IV or retrograde contrast can evaluate other causes.

SELECTING A RADIOLOGIC APPROACH

Ultrasound

➤ Advantages

- Fast
- Detect obstruction/hydroureter
- Avoid radiation
- Quantify: length, echogenicity
- 96% sensitivity, 98% NPV

➤ Disadvantages

- Operator-dependent
- Poor visualization past proximal ureter.

Used for initial triage to determine possible causes.



Ultrasound demonstrating ureterolithiasis at proximal ureter.
Echogenic focus with distal shadowing.
[Moş et al, 2010]

SELECTING A RADIOLOGIC APPROACH

CT Urogram (CTAP, with and without IV contrast)

- Advantages
 - Almost all stones are radiopaque
 - Use CT attenuation to determine stone makeup
 - Visualize relation between stone and ureter
 - Prone position: identify stone at UVJ
 - Identify *alternate diagnoses*
 - Obstruction: delayed nephrogram → dense nephrogram → delayed pyelogram with dilated pelvis/calices
- Disadvantages
 - Expensive
 - Radiation Exposure
 - IV Contrast



Non-contrast axial CT demonstrating calculus in distal left ureter.
[Case courtesy of Dr Varun Babu, Radiopaedia.org, rID: 46796]

Gold standard for diagnosis of ureterolithiasis.

Shen L, Raman S, Beland M, et al. ACR Appropriateness Criteria® Hematuria. Available at <https://acsearch.acr.org/docs/69490/Narrative>. American College of Radiology. Accessed August 16, 2016..
Case courtesy of Dr Varun Babu, Radiopaedia.org, rID: 46796



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INDEX CASE: IMAGING

- CT Urogram performed:
 - “5 mm nonobstructing right renal stone.”
 - “No hydronephrosis or solid renal mass.”
 - “Bilateral renal cysts.”
- Plan: repeat imaging in 1 year.



CT Urogram demonstrating radiopaque, hyperdense area at proximal ureter/renal pelvis consistent with urolithiasis.



INDEX CASE: IMAGING

- 1 year later: GU Ultrasound
 - “Nonobstructing calculus in the lower pole of the right kidney. Similar to prior exam.”
- Plan: definitive management.



Ultrasound sagittal view of lower pole of right kidney.

MANAGEMENT OF URETEROLITHIASIS

- Stone < 4 mm: spontaneous passage in most
- Stone < 10 mm: medical therapy → spontaneous passage
- Larger stone or proximal ureteric location:
 - Open renal/ureteral surgery
 - Minimally invasive procedures:
 - Percutaneous nephrolithotomy
 - Rigid and flexible ureteroscopy
 - **Laser lithotripsy**

INDEX CASE: MANAGEMENT

Laser lithotripsy:

- Preferred treatment for stones at proximal ureter
- Use holmium laser with ureteroscopy to fragment stone within ureter



Holmium laser aimed at stone, viewed by ureteroscope. Image from the online image library of the Southern African Endourology Society.



COMPLICATIONS OF LITHOTRIPSY

- Ureteral Perforation
- Hemorrhage
- Urinoma
- Ureteral Obstruction (Steinstrasse)
- Infection / Abscess → Urosepsis → Death

Mittal V, Srivastava A, Kappor R, Ansari MS, Patidar N, Arora S, et al. Standardized Grading of Shock Wave Lithotripsy Complications with Modified Clavien System. Urol Int 2016;0.



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INDEX CASE: RE-PRESENTATION

- CC: 54 year-old male with severe bilateral lower abdominal pain.
- HPI: S/P right ureteroscopy and laser lithotripsy 10 hours ago. Now with bilateral lower abdominal pain, sharp, constant, and severe, worse with movement and deep breathing
- ROS: Endorses nausea. Denies any other symptoms.
- Exam: T 99.7 HR 70 BP: 178/114 RR: 16 SaO2: 98
CV/Resp: RRR/CTAB Abd: rebound tenderness
GU: No CVAT Extremities: No cyanosis/clubbing/edema

INDEX CASE: RE-PRESENTATION

- CC: 54 year-old male with severe **bilateral lower abdominal pain**.
- HPI: **S/P right ureteroscopy and laser lithotripsy** 10 hours ago. Now with bilateral lower abdominal pain, sharp, constant, and severe, worse with movement and deep breathing
- ROS: Endorses nausea. Denies any other symptoms.
- Exam: T 99.7 HR 70 BP: 178/114 RR: 16 SaO2: 98
CV/Resp: RRR/CTAB Abd: rebound tenderness
GU: No CVAT Extremities: No cyanosis/clubbing/edema

Next step: radiologic assessment

ACR APPROPRIATENESS CRITERIA

RENAL TRAUMA: Penetrating injury, with or without hematuria.

PROCEDURE	RATING	COMMENTS	RRL
CTAP with IV contrast	9		4
CTAP without IV contrast	5	<i>If IV contrast contraindicated.</i>	4
X-ray AP (KUB)	4	<i>For foreign body.</i>	3
X-ray IV urography	4	<i>In OR, if patient cannot get CTAP.</i>	3
Arteriography kidney	4	<i>Embolize bleed.</i>	3
US Abdomen (FAST scan)	4	<i>For free intraperitoneal fluid.</i>	0
CTAP with and without IV contrast	3	<i>CTAP without contrast not useful in conjunction.</i>	4
US kidney/bladder, retroperitoneal	2		0

AP = Abdomen and Pelvis. RRL = Relative Radiation Level



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SELECTING A RADIOLOGIC APPROACH

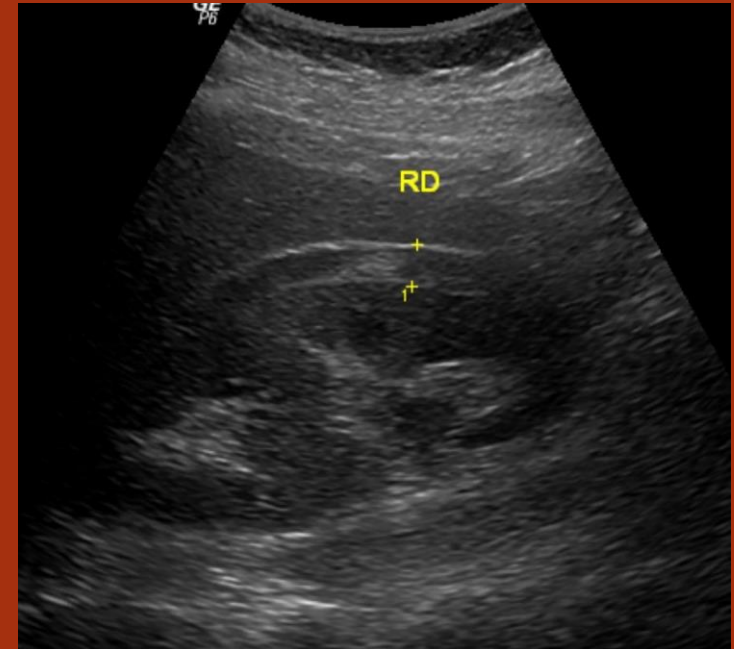
FAST Ultrasound Scan

➤ Advantages

- Widely used (operators familiar)
- Rapid, at bedside
- Noninvasive, minimal radiation
- 95% accuracy, 99.9% NPV
- Identify free intraperitoneal fluid – can triage to surgery
perihepatic/perisplenic/pelvic + pericardial

➤ Disadvantages

- Poor visualization of ureter
- No functional information
- Operator-dependent



Ultrasound demonstrating a heterogeneous, hypoechoic fluid collection beneath the capsule of the right kidney, consistent with a perirenal hematoma following lithotripsy.

[Case courtesy of Dr Bruno Di Muzio, Radiopaedia.org, rID: 30289]

Use as initial screen for intraperitoneal fluid if hemodynamically unstable and expected delay to CTAP.

SELECTING A RADIOLOGIC APPROACH

CTAP with contrast

➤ Advantages

- Fast and accurate detection of abdominal injury
- Complete visualization of ureter
- Differentiate urinoma vs. hemorrhage via extravasation and CT attenuation
 - Urinoma – extravasated contrast from ureter
 - Hemorrhage – higher attenuation than normal fluid

➤ Disadvantages

- Radiation Exposure
- Expensive
- IV Contrast



CTAP with contrast, coronal, demonstrating contrast extravasation consistent with ureteric rupture [Case courtesy of Hugo Neves (RT), Radiopaedia.org, rID: 23596]



SELECTING A RADIOLOGIC APPROACH

CTAP with contrast

Gold standard in the hemodynamically stable patient with suspected penetrating intra-abdominal injury



CTAP with contrast demonstrating perinephric fluid consistent with ureteric rupture.

[Case courtesy of Dr Jeremy Jones, Radiopaedia.org, rID: 6149]



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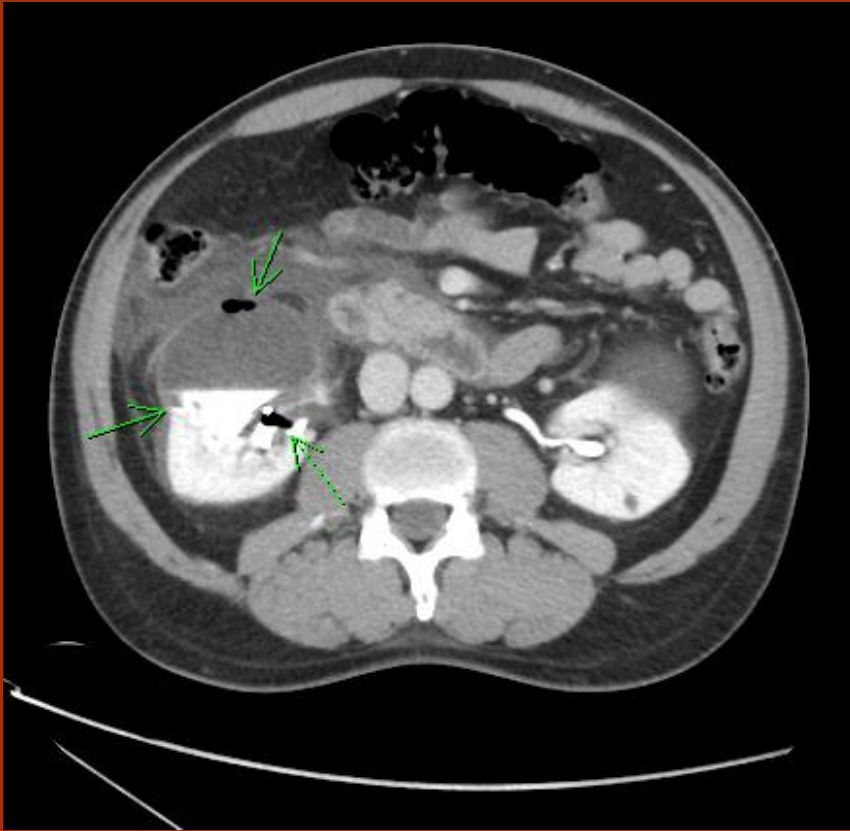
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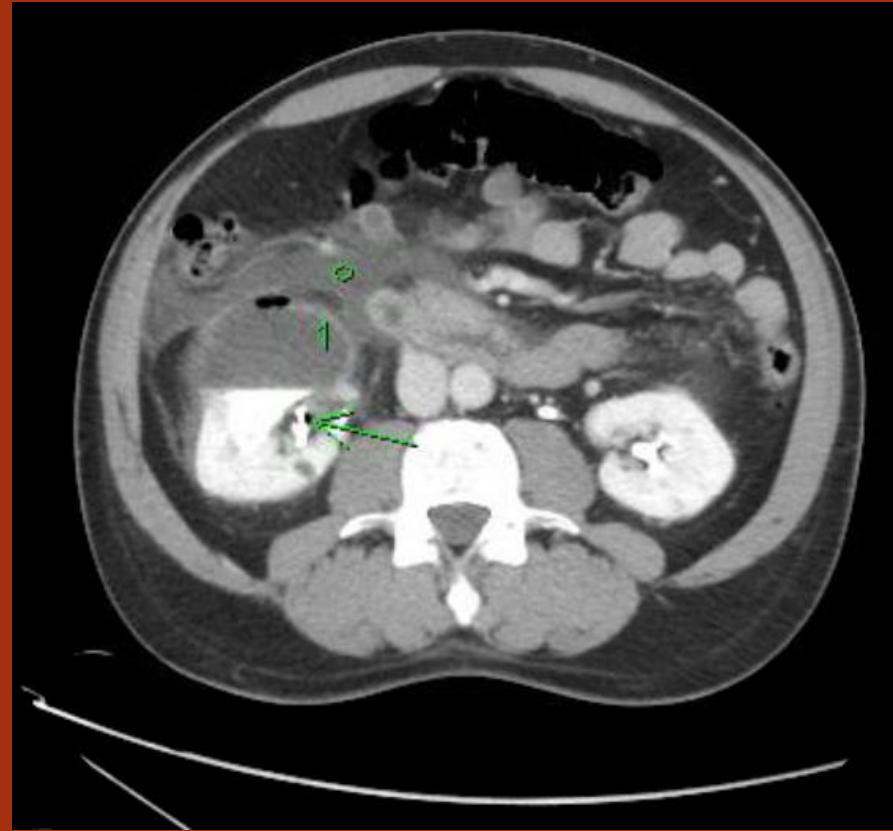
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Case courtesy of Dr Jeremy Jones, Radiopaedia.org, rID: 6149

INDEX CASE: IMAGING

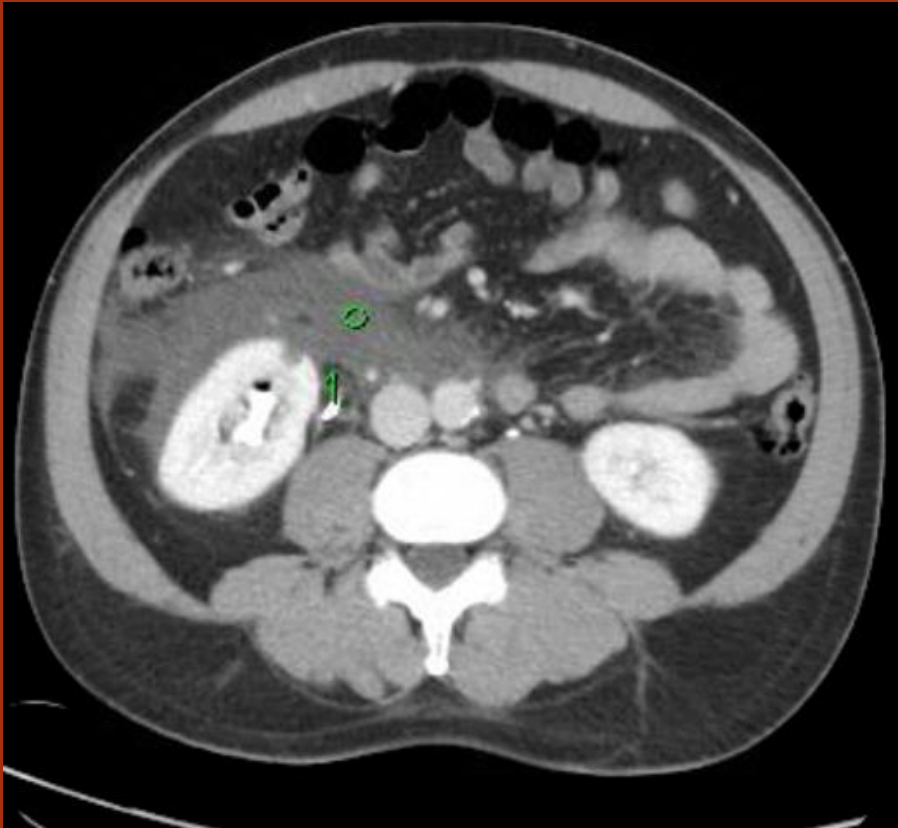


CTAP with contrast: Image 40



CTAP with contrast: Image 41

INDEX CASE: IMAGING



CTAP with contrast: Image 45



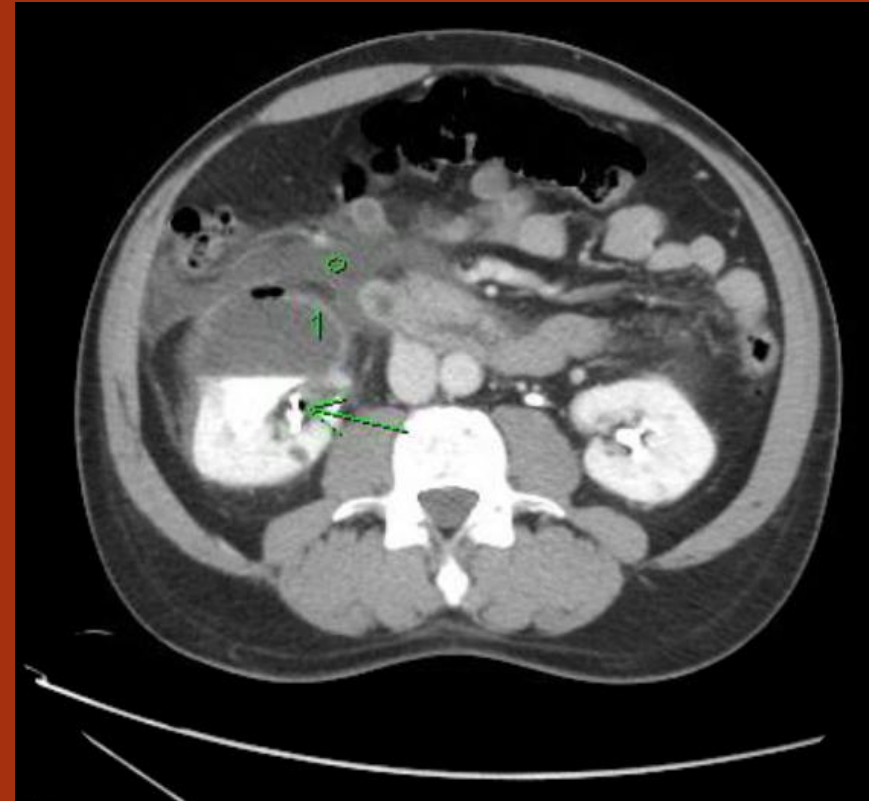
CTAP with contrast: Image 78



INDEX CASE: IMAGING

CTAP with contrast

- *Double-J right ureteral stent with distal portion in bladder.*
- *Excreted IV contrast traverses from calyx into the right renal cyst which on previous CTU did not fill with contrast.*
- *Air is found at renal cyst and within right collecting system, adjacent to the proximal ureteral stent.*
- *Perinephric non-hemorrhagic fluid tracks along right ureter to right inguinal region.*



CTAP with contrast: Image 41

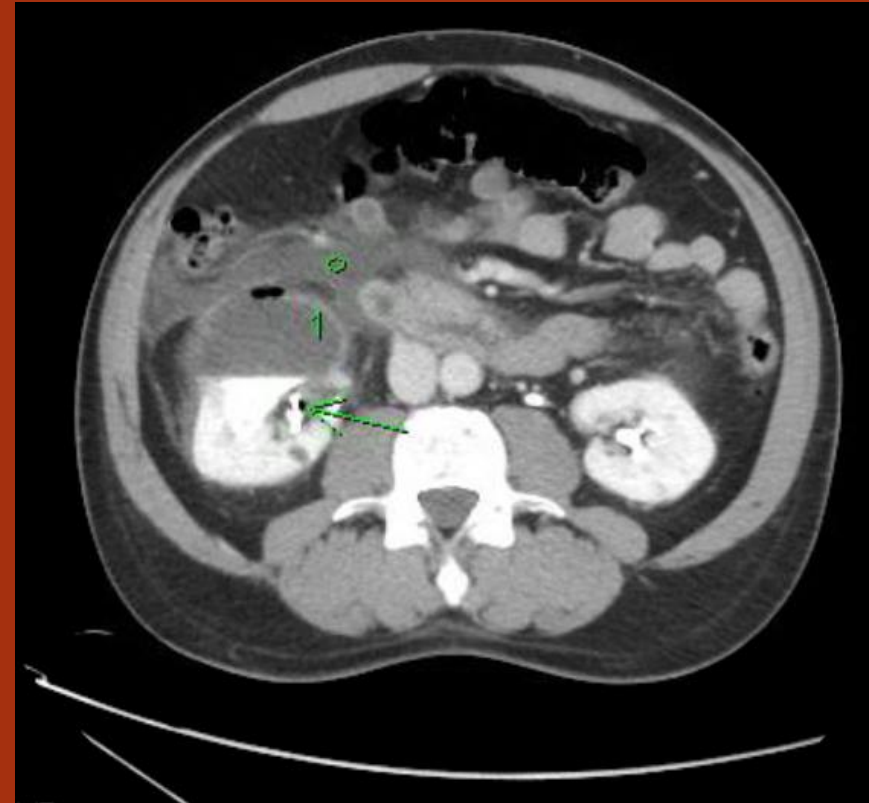
INDEX CASE: IMAGING → MANAGEMENT

CTAP with contrast

Diagnosis: Ureteric perforation

Management: inpatient admission for analgesia only, as CTAP does not show urine in peritoneum/retroperitoneum (Minor injury, hemodynamically stable – Grade I/II)

- Grade III/IV injury – manage by stent placement or open surgery
- Grade V injury – nephrectomy



CTAP with contrast: Image 41

CONCLUSIONS: ROLE OF RADIOLOGY

- While initial suspicion for urolithiasis is clinical, management at all subsequent steps is dependent on radiologic assessment.
 - Initial workup to identify calculi: CT Urogram / Screening Ultrasound
 - Choosing initial treatment option for calculi: Assessment of size/location by CT Urogram or Ultrasound
 - Post-treatment surveillance to identify change in calculi: Follow-up CT Urogram / GU Ultrasound
 - Initial workup of acute complications – e.g. ureteral perforation: FAST Ultrasound / CTAP with contrast
- Different information is required at different steps – this guides the choice of imaging.

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THANK YOU!