CT Urography Update: CTU, MRU or Nothing?

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CT Urography Update: CTU, MRU or Nothing?

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Disclosures
Galil Medical Ltd. Yokneam, Israel – Consultant
Lippincott, Williams, and Wilkins Philadelphia, PA – Book Royalties
Urinary Tract CT Protocols

- Flank pain -> UP ("Stone protocol")
- Renal mass -> UP, NP, Excretory
- Congenital anomalies -> Excretory
- Partial nephrectomy -> AP, VP, Excretory
- Post operative complication -> Excretory
- Trauma -> NP, Excretory

UP = unenhanced phase; NP = nephrographic phase
AP = arterial phase; VP = venous phase
BWH CTU Protocols

Patients > 40 years old

- Three phase – UP (abdomen and pelvis), NP (kidneys only), EP (abdomen and pelvis), supplemented with 10 mg furosemide IV

Patients ≤ 40 years old

- Split bolus, two phase – abdomen and pelvis, supplemented with 250 cc saline IV
## BWH CT Urography Protocol

### 64 - Channel MDCT with 3 phases

<table>
<thead>
<tr>
<th>Unenhanced</th>
<th>Nephrographic</th>
<th>Excretory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>Abd/Pel</td>
<td>Kidneys</td>
</tr>
<tr>
<td>Delay</td>
<td>--</td>
<td>100 s</td>
</tr>
<tr>
<td>Collimation</td>
<td>1.2 mm</td>
<td>1.2 mm</td>
</tr>
<tr>
<td>Axial Recon/Incr</td>
<td>3/3</td>
<td>3/1.5</td>
</tr>
<tr>
<td>Post Processing</td>
<td>--</td>
<td>Cor / Sag / MIP / CPR / VR</td>
</tr>
</tbody>
</table>

Iodinated contrast material (300 mgI/ml); 0.5 s rotation time
AEC w/ quality reference 200 mAs, 120 kVp

Silverman et al Radiology 2006
BWH CTU Protocol for pts < 40 y.o.

**Split dose**: 370 mg/ml

- **Unenhanced**
  - Range: Abd/Pel
  - Delay: --
  - Collimation: 2.5 mm
  - Axial Recon/Incr: 3/3
  - Post Processing: --
  - Post Processing: Cor / Sag / MIP / CPR / VR

- **NP + EP**
  - Range: Abd/Pel
  - Delay: 6 min
  - Collimation: 2.5 mm
  - Axial Recon/Incr: 3/3
  - Post Processing: Cor / Sag / MIP / CPR / VR

Modified from Chow and Sommer AJR 2001

Obtaining NP and PP during one scan reduces radiation dose.
BWH MRU – Bladder Focus

- Sag Single Shot FSE (HASTE or SSFSE) - pelvis
- Sag, Cor, Ax T2W FSE - pelvis
- Cor Single Shot FSE FS 20mm BH - ureters
- Sag, Cor 3D GRE (LAVA or VIBE) FS - pelvis
- Inject 10 mg IV Furosemide (or 250 cc NS at start)
- Ax 3D GRE FS Pre - pelvis
- Inject CM, then Ax 3D GRE FS x 3 - pelvis
- Sag, Cor 3D GRE FS - pelvis
- Ax 3D GRE FS - kidneys
- Cor 3D GRE high FA - ureters

Static Fluid

MRU Pre

Excretory Phase

MRU Post Contrast

“IVP delayed”
BWH MRU – Kidney Focus

- Sag, Cor, Ax Single Shot (HASTE or SSFSE) - kidney
- Sag, Cor, Ax T2W FSE - kidney
- Ax T1 Dual Echo In/Out of Phase - kidney
- Ax DWI (0/250/500/1000 or 0/500) - kidney
- Cor Single Shot FSE FS 20mm BH - ureters
- Inject 10 mg IV Furosemide (or 250 cc NS at start)
- Ax 3D GRE (LAVA or VIBE) FS Pre - kidney
- Inj CM, then Ax 3D GRE FS Post x3- kidney
- Ax 3D GRE FS - pelvis
- Cor 3D GRE high FA – ureters
CTU vs IVU (N=74)

7 of 10 members of SUR use CTU more than 75% of time to image urinary tract

26% use CTU exclusively

Townsend et al, JCAT 2009
What are the Issues?

What is good about CTU?
- CTU is a sensitive, accurate, and comprehensive exam of the urinary tract.
- CTU is available, safe, well-tolerated, and reproducible.

What is bad about CTU?
- CTU results in substantial radiation dose (15 mSv or more) to patients.
- CTU is costly.
Indications: CT Urography

- Hydronephrosis ?etiology
- Hematuria
- Suspected urothelial cancer (e.g., positive urine cytology)
- Follow-up urothelial cancer
- Others (eg, pre/post ablation)
Differential Diagnosis of Asymptomatic Microscopic Hematuria

**Life Threatening**
- Malignancy, AAA

**Significant Requiring Treatment**
- Urolithiasis, BPH with Sx, VUR, UPJ obstruction, RAS, RVT, infection

**Significant Requiring Observation**
- BPH without Sx, papillary necrosis, trauma, AVF

**Insignificant**
- Renal cyst, exercise, polyps, urethritis, urethrotrigonitis

Modified from Grossfeld and Carroll, UCNA 1998
Hematuria - Yield varies by Type

- **Gross hematuria**
  23% have urologic cancers

- **Microscopic hematuria**, defined as $\geq 3$ RBCs / hpf, is present in 9-18% normals (Maccioni, 1989)

- **PPV of microscopic hematuria** typically in the 20-30% range
  (Woodlander JAMA 1989)
Asymptomatic Hematuria

“No data exist showing the impact of IVU, ultrasonography, CT or MRI on the management of patients with microscopic hematuria. Therefore, evidence-based imaging guidelines cannot be formulated.”

AUA recommendations: Grossfeld et al, Urology 2001
Risk Factors for Urologic Disease

- Age > 40 years
- Smoking
- Gross hematuria
- Irritative voiding symptoms
- Urinary tract infections
- Exposure to carcinogens: pelvic irradiation, analgesic abuse, cyclophosphamide, chemicals/dyes (benzenes, aromatic amines)
AUA 2001: High Risk Patients

One positive urine sediment $> 3$ RBC/hpf

Upper tract imaging, cytology, cystoscopy

If negative, repeat W/U every yr x 3 yrs

AUA 2001: Low Risk Patients

2 of 3 positive urine sediments > 3RBC/hpf

Upper tract imaging, cytology, cystoscopy

If negative, further W/U optional

Imaging for Hematuria: AUA ‘01

Upper tract imaging recommendation:

IVU or CTU

<table>
<thead>
<tr>
<th>Exam</th>
<th>Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT Urography</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>IVU</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>US (renal/bladder)</td>
<td>6</td>
<td>May miss urothelial lesions</td>
</tr>
<tr>
<td>Retro Pyelography</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>MR Urography</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>CT (A/P)</td>
<td>4</td>
<td>May follow IVU or US</td>
</tr>
<tr>
<td>Angiography</td>
<td>4</td>
<td>To detect AVM</td>
</tr>
<tr>
<td>KUB</td>
<td>2</td>
<td>May be coupled with US</td>
</tr>
<tr>
<td>MRI (A/P)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Scintigraphy</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Virtual cystoscopy</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Choyke et al, ACR 2005
Imaging Algorithm for Hematuria

This algorithm is simpler, and faster than when IVU was used as the initial test for hematuria.
Is CTU Good in Detecting UT TCC?

82 (3%) positive CT urograms (n=2602)

True Positive: 43
False Positive: 39

PPV: 43/82 = 52%

Wheeler S et al, SUR 2008
Is CTU Good in Detecting UT TCC?

- **Large Mass (>5 mm)**: CTU + 36, True + 29, PPV = 81%
- **Small Mass (<=5 mm)**: CTU + 17, True + 0, PPV = 0%
- **Urothelial Thickening**: CTU + 29, True + 14, PPV = 48%

Wheeler S et al, SUR 2008
Imaging Algorithm for Hematuria

MDCTU

Renal cyst → Renal mass → Normal → Retro Pyelogram

MRI

Urothelial abn

Thickening?

Note.- Retrograde pyelography may still be needed when CTU is positive...
Bladder Ca Detection (n=838)

Negative Predictive Value of CTU

- Microscopic Hematuria: 0.984, n=249
- Gross Hematuria: 0.971, n=373
- Urothelial CA: 0.769, n=158

Sadow et al Radiology 2008
AUA 2001: Low Risk Patients

2 of 3 positive urine sediments > 3RBC/hpf

CT urography, cytology, cystoscopy

If negative, further W/U optional

CTU in pts < 40 w/ Hematuria

- Significant findings found uncommonly
  [44 (22%) of 204]
- Of 44 significant causes found, 33 (75%) were due to urolithiasis
- All but 3 significant findings were seen on unenhanced CT alone
- All 3 cases had predisposing conditions!
- 4 false positive CT urograms would not have been found on unenhanced CT

Sadow et al RSNA 2007
Unless there is a predisposing condition, it may be appropriate to perform only unenhanced CT in pts < 40 with hematuria.

But more data are needed...
CTU in 80 pts after cystectomy

- I+ AP CT was adequate in diagnosing local recurrence and distant mets.
- CTU was needed to diagnose urinary diversion malfunction or leakage.
- CTU may be needed to diagnose UTT, but was not necessary in this series - the prevalence of UTT (1/80, 1.5%) was lower than reported (2-7%).

Sadow et al, RSNA 2007
## CTU in pts after cystectomy

<table>
<thead>
<tr>
<th></th>
<th>Early (&lt;1yr)</th>
<th>Late (&gt;1yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CTU</strong></td>
<td>Post-op Complications</td>
<td>UTT</td>
</tr>
<tr>
<td><strong>I+A/P</strong></td>
<td>LR, Mets Calculi</td>
<td>LR, Mets Calculi</td>
</tr>
</tbody>
</table>

CTU early if Cx suspected; use late?

Sadow et al, RSNA 2007
MRU Indications

- Iodinated CM allergy
- Renal Insufficiency (Static-fluid MRU)
- Pregnancy (Static-fluid MRU)
- Young patients, need for serial f/u

Patient populations...

...CT relatively contraindicated
<table>
<thead>
<tr>
<th>CT Urography</th>
<th>MR Urography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation</td>
<td>No radiation</td>
</tr>
<tr>
<td>Attenuation, CE</td>
<td>T1,T2,CE,FS,CSI,DWI</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>Contrast resolution</td>
</tr>
<tr>
<td>Furosemide helpful</td>
<td>Furosemide required</td>
</tr>
<tr>
<td>Risk of CIN</td>
<td>Risk of NSF</td>
</tr>
<tr>
<td>Short examination</td>
<td>Long examination</td>
</tr>
<tr>
<td>Sensitive for Ca^{2+}/stones</td>
<td>Sensitive for UT tumors</td>
</tr>
<tr>
<td>Sensitive for UT tumors</td>
<td>Unk. sensitivity for UT</td>
</tr>
<tr>
<td>Consistent IQ</td>
<td>Inconsistent IQ</td>
</tr>
</tbody>
</table>
MRU Indications

What if iodinated CM allergy?

- If mild, CTU after pre-medicating
- If severe, MRU

What if pregnant?

- If pain, abd MRI + evaluate for appy
- If hydronephrosis etiology -> static-fluid MRU
MRU Indications

What if eGFR 30-60?
- Unenhanced CT
- CTU at \( \frac{1}{2} \) dose CM
- MRU
- MRU at \( \frac{1}{2} \) dose CM
- MRU static – fluid only

What if eGFR <30?
- Unenhanced CT or static-fluid MRU
Tailor CTU Protocols further?

Patients with risk factors for malignancy

- Three phase – UP (abdomen and pelvis), NP (kidneys only), EP (abdomen and pelvis), supplemented with 10 mg furosemide IV

Patients with no risk factors for malignancy

- Split bolus, two phase – abdomen and pelvis, supplemented with 250 cc saline IV
- Unenhanced CT alone if ≤ 40 years of age?
## Tailor CTU Protocols further?

Evaluation of painless microscopic or macroscopic haematuria

<table>
<thead>
<tr>
<th>Probability TCC</th>
<th>Lowest</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haematuria</td>
<td>Micro</td>
<td>Macro</td>
<td>Micro</td>
<td>Macro</td>
</tr>
<tr>
<td>Patient age</td>
<td>&lt;40 years</td>
<td>&lt;40 years</td>
<td>&gt;40 years</td>
<td>&gt;40 years</td>
</tr>
<tr>
<td>First line tests</td>
<td>CYS</td>
<td>CYS</td>
<td>CYS</td>
<td>CYS</td>
</tr>
<tr>
<td></td>
<td>US</td>
<td>US</td>
<td>US</td>
<td>US</td>
</tr>
<tr>
<td>Follow-up</td>
<td>Watch &amp; wait if negative</td>
<td>CTU if US &amp; CYS negative and symptoms persist</td>
<td>NVU &amp; CTU if US &amp; CYS negative and symptoms persist</td>
<td>Specialist referral</td>
</tr>
</tbody>
</table>

Risk-based approach is on the right track!

Van Der Molen et al (ESUR) European Radiology 2007
Role of CTU and MRU

- CTU is the imaging test of choice for the evaluation of the upper urinary tract.
- MRU indicated if allergy to iodinated CM, pregnancy, renal insufficiency, young patients