Demonstration of an Effective Ultra Low Dose CT Protocol with Lower Radiation Dose than Abdominal X-Ray

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I have no conflict of interest to disclose
How do we identify calculi?

The problem:
• Need for effective imaging
• Need to minimize radiation exposure

The traditional modality options:
• Non contrast CT A/P
• Low dose CT (CT-KUB)
• KUB abdominal X-ray
How do we identify calculi?

The problem:

• Need for effective imaging
• Need to minimize radiation exposure

Novel modality:

Ultra low dose CT (ULDCT)
How does ULDCT compare to KUB?

Issues of concern:
- Quality degraded CT examination
- Negative predictive value of CT is reduced

Hypothesis: ULDCT superior to KUB at:
- Detecting symptomatic calculi
- Lower radiation exposure

Methods:

- Prospectively recruited 104 patients

- Pre-procedure
  - Abdominal Radiograph
  - Ultralow dose CT (ULDCT)

- Exclusions
  1. BMI >30
  2. Conventional Dose CT <100 days

83 patients included in study
Patient demographics

- 83 patients included in study

- Prevalence of calculi
  - 100%

- 41 Ureteric Calculi
  - 14 with hydronephrosis
  - Size 7.7±3.6mm

- 234 Renal Calculi
  - Majority measuring less than 2mm
Identification of calculi is superior in ULDCT

KUB 0.54±0.11 mSv  ULDCT 0.28±0.08 mSv  CT 6.06±3.08 mSv
## KUB abdominal radiograph

<table>
<thead>
<tr>
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<th>True Positive</th>
<th>False Positive</th>
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<tbody>
<tr>
<td>True Negative</td>
<td>33</td>
<td>3</td>
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<tr>
<td>False Negative</td>
<td>8</td>
<td>39</td>
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6 measuring >5mm

### Diagnostic Performance

- **PPV** = 83%
- **NPV** = 92%
- **Sensitivity** = 80%
- **Specificity** = 93%
ULDCT 48% lower radiation dose than KUB

KUB 0.64 mSv  
ULDCT 0.31 mSv  
CT 9.3 mSv
## Ultra Low Dose CT

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<th>True Positive</th>
<th>False Positive</th>
<th>True Negative</th>
<th>False Negative</th>
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<tr>
<td><strong>Count</strong></td>
<td>39</td>
<td>1</td>
<td>41</td>
<td>2</td>
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<td><strong>Both measure &lt;2mm</strong></td>
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### Diagnostic Performance
- PPV = 98%
- NPV = 95%
- Sensitivity = 95%
- Specificity = 98%
Conclusions

• ULDCT has significantly greater:
  o Sensitivity, Specificity, PPV, NPV
  o ~50% effective dose of a KUB

• ULDCT use would significantly reduce lifetime radiation exposure

• Limitations
  o Poor identification of sub 2mm calculi
  o Increased demands to review
Thank You!

Questions?
Initial Presentation

**Non-contrast CT abdomen and pelvis/KUB* Standard protocol**

- Abdominal / Flank / Back Pain

  - BMI < 30
    - Yes: Non-contrast CT abdomen and pelvis/KUB* Low dose protocol**
      - Yes: Ureteral calculus
      - No: Further workup for etiology of symptoms as indicated
    - No: Report:
      - Stone size
      - Stone location
      - Stone Attenuation
      - Skin to stone distance
      - Hydro nephrosis
      - Congenital anomalies
      - Extravasation
      - Stranding

  - Yes: Management Per AUA Guidelines

  - Definitive Interventional Management
  - Observation / Medical Management

Exceptions:
- Known radio-opaque stone former
- Contrast allergy
- Renal insufficiency
- Pregnancy (ACOG)
- Pediatric patients

* KUB is obtained if stone is not seen on CT scout film
** Low dose protocol not recommended for patients with BMI>30

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**Recommendation**

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**NCCT should be used to confirm stone diagnosis in patients with acute flank pain, because it is superior to IVU (10).**

**NCCT can detect uric acid and xanthine stones, which are radiolucent on plain films, but not indinavir stones.**
Radiation

• Per capita annual effective dose from CT:*
  USA 0.5 mSv in 1982
  3.0 mSv in 2006 (6x)
  Canada 0.19 mSv in 1991
  0.74 mSv in 2006 (3.9x)

• ED CT use in renal colic increased 7-12x 1996-2008**

• 79% evaluated for renal colic in ED underwent ≥2 CT, with median dose of 14.5 mSv***

*Chen J, J Radiol Prot 2010
**Dalziel JD, Emerg Med J 2013
MDCT dose: How low can we go? ALARA

- Ultra-low dose scanning possible with use of low noise detectors and iterative & model-based reconstruction
- Patient selection key