Limited Field Noncontrast Computerized Tomography for Followup of Ureteral Stones: Initial Results

Yuval Freifeld,*,† Avi Stein,† Ofir Avitan, Roni Mulner, Sharbel Hashoul, Tal May, Ilan Benyamin Klein, Leonid Boyarsky, Dmitry Goldin, Yoel Mecz, Natan Peled‡ and Yoram Dekel

Urology and Radiology (RM, SH, NP) Departments, Carmel Medical Center, Technion, Ruth and Bruce Rappaport Faculty of Medicine, Haifa, Israel

Purpose: Due to high specificity and sensitivity noncontrast computerized tomography is increasingly used to diagnose and follow patients with ureteral stones. We evaluated the feasibility of limited field noncontrast computerized tomography to follow patients with ureteral stones.

Materials and Methods: Included in the study were 71 patients who underwent diagnostic and followup noncontrast computerized tomography due to ureteral stones. According to stone position on the first diagnostic scan a limited field batch from the followup scan was formed and examined by an independent radiologist. Radiation doses and rates of potentially missed findings in the batch were compared to those of the full followup noncontrast scan.

Results: Average full followup noncontrast computerized tomography length was 46.5 cm and average batch length was 20.7 and 13.8 cm for proximal and distal stones, respectively. The average full followup noncontrast scan radiation dose was 12.2 mSv. Average batch doses were 6.1 and 4.1 mSv for proximal and distal stones, respectively ($p = 0.002$), resulting in a radiation exposure reduction of 48.8% for proximal stones and 66% for distal stones. In 3 cases additional clinical information (not including hydronephrosis) was missed when relying only on batch images. This additional information did not impact further urological treatment.

Conclusions: Limited field noncontrast computerized tomography is a feasible option for following patients diagnosed with ureteral stones. It may lead to significantly lower radiation exposure.

Key Words: ureter; calculi; tomography, x-ray computed; radiation dosage; diagnosis

Abbreviations and Acronyms

CT = computerized tomography

DLP = dose length product

ESWL = extracorporeal shock wave lithotripsy

KUB = plain x-ray of kidneys, ureters and bladder

MET = medical expulsive therapy

NCCT = noncontrast computerized tomography

Accepted for publication March 24, 2014.

Study received local ethics committee approval.

* Correspondence: Urology Department, Carmel Medical Center, Michal 7 St., Haifa, Israel (telephone: +972-48250843; FAX: +972-48250122; e-mail: Yuvalfr@clalit.org.il).

† Equal study contribution.

‡ Financial interest and/or other relationship with Phillips Medical Systems.

Presented at annual meeting of American Urological Association, San Diego, California, May 4-8, 2013.

Urinary calculi are common worldwide. The prevalence of stone disease seems to be increasing with a lifelong prevalence exceeding 10% in American males.[1] According to EAU (European Association of Urology) guidelines NCCT is currently the imaging study of choice for diagnosing patients with acute flank pain.[2] Although KUB and ultrasound are often used to follow patients with ureteral stones, they are less sensitive than NCCT.[3]

Since followup imaging is increasingly performed before surgical intervention and chronic stone formers are prone to recurrent episodes of flank pain, NCCT use is increasing and patients may be exposed to radiation

0022-5347/14/1923-0781/0
THE JOURNAL OF UROLOGY®

http://dx.doi.org/10.1016/j.juro.2014.03.104
Vol. 192, 781-785, September 2014
Printed in U.S.A.

doses as high as 50 mSv during 1 year of followup.[4] The lifetime attributable risk of cancer may be increased as a result of radiation exposure.[5,6] Low\ultralow dose CT protocols were suggested but sensitivity may be lower for small ureteral stones and in patients with a high body mass index.[7–9]

We suggest a new concept of NCCT for following ureteral stones that uses only a limited field of exposure set according to stone location at diagnosis instead of full abdominopelvic CT. Using this method a significant reduction in radiation dose may be achieved.

MATERIALS AND METHODS

After obtaining approval from the local ethics committee 71 patients diagnosed with a single ureteral stone by NCCT who received MET were prospectively recruited for study. All signed an informed consent form. Patients who eventually required ureteral decompression or any other invasive procedure, including ureteral manipulation, before followup CT were excluded from study.

All patients underwent standard NCCT at diagnosis. A second full followup standard NCCT was performed within 60 days of the first CT in all patients who did not report stone expulsion. All scans were done using the iCT 256 or Brilliance 64 multidetector scanner (Philips Healthcare, Cleveland, Ohio). A batch of images was created from the followup CT. Batch limits were calculated according to stone position as seen on the diagnostic CT. The upper limit was set as 1 vertebra proximal to the stone position for stones in the proximal ureter and as the pelvic brim for distal and mid ureteral stones. The latter stones were grouped together for statistical analysis and are referred to as distal stones. The lower limit of the batch was the last image including the bladder base. Figure 1 shows an example of batch limits for a distal ureteral stone.

The batches were interpreted by 1 radiologist (RM) and the full NCCT studies were interpreted by a second radiologist (SH). Radiologists were blinded to full CT and batch images, respectively. Interpretation reports were compared and any pathological finding noted on the full scan but missed using only the batch images was noted. Thus, we evaluated information that may have potentially been lost if followup CT had been performed only within the batch limits.

Radiation exposure was calculated in mSv for all batches and full CT studies, and the radiation dose reduction was calculated for batches. Radiation doses for full followup NCCTs were extracted from the DLP data of the CT scanner. DLP for the limited field batch was estimated using the equations,

$$\mathrm{DLP}_{\mathrm{i[m\ Gy^{*}cm]}} = \frac{(\mathrm{CTDI}_{x} + \mathrm{CTDI}_{x+2.5cm})}{2} \times 2.5 \quad \text{and}$$

$$\mathrm{DLP}_{\mathrm{batch[m\ Gy^{*}cm]}} = \sum_{i=1}^{k} \mathrm{DLP}_{\mathrm{i[m\ Gy^{*}cm]}} + (\mathrm{CTDI}_{\mathrm{Init}} + \mathrm{CTDI}_{\mathrm{Final}}) \times \frac{\mathrm{Overscan}_{[cm]}}{2} \times \mathit{CollFactor}.$$

CT dose index data were collected in 2.5 cm intervals. The average of each 2 samples was multiplied by 2.5 cm (length of the scan) to arrive at $\mathrm{DLP_i}$. Each scan performed by a helical multidetector CT scanner has a certain amount of overscan. Overscan length was calculated using scan length, time and velocity data according to the equation,

$$\mathit{Overscan}_{[mm]} = \mathit{ScanSpeed}_{[mm/sec]} \times \mathit{ScanTime}_{[sec]} - \mathit{ScanLength}_{[mm]}.$$

These data was integrated into the DLP formula and further multiplied by the CT dose index of the first and last images, as shown in the equation above for calculating $\mathrm{DLP_{total}}$.

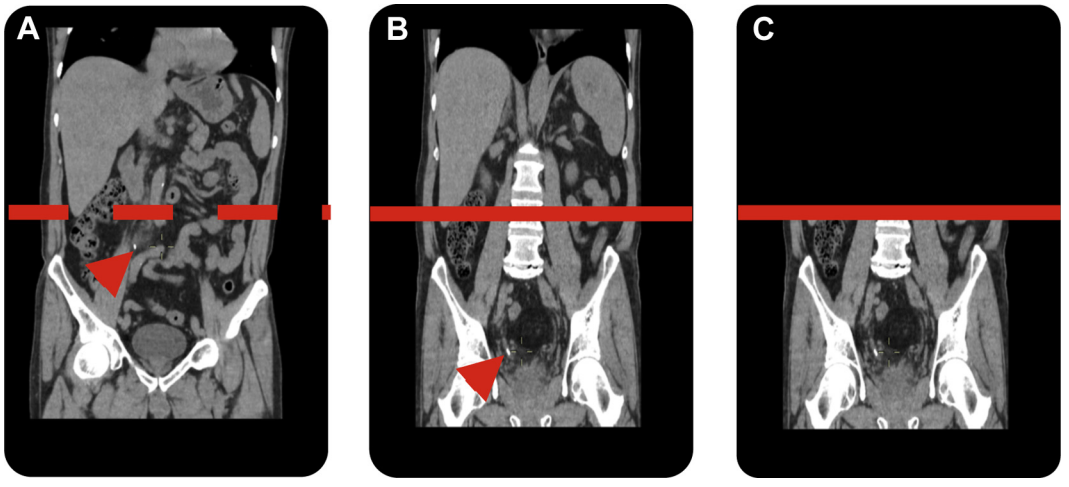

Figure 1. *A*, diagnostic CT shows ureteral stone (arrow). Dotted line indicates upper limit of batch images. *B*, second full followup CT in same patient shows ureteral stone (arrow) distal to prior location. Line indicates upper batch limit. *C*, batch images form limited field CT, comprising images from second CT according to stone site on diagnostic CT (*A*).