Value of Automated Coronal Reformations From 64-Section Multidetector Row Computerized Tomography in the Diagnosis of Urinary Stone Disease

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Purpose: We determined the value of automated coronal reformation using 64-detector computerized tomography for the detection of urinary stones.

Materials and Methods: A total of 72 patients underwent unenhanced 64-detector computerized tomography to diagnose urinary stones. Two radiologists independently reviewed coronal reformations and axial images at separate reading sessions. The stone detection rate, reader confidence and interpretation time per radiologist were recorded. Two radiologists reviewed coronal and axial images in consensus and served as the reference standard.

Results: A total of 175 stones were diagnosed by consensus. Using coronal reformations 162 stones (92.6%) were detected by reader 1 and 157 (89.7%) were detected by reader 2. Using axial images 157 stones (90.3%) were detected by reader 1 and 155 (88.6%) were detected by reader 2. The reading time of coronal reformations was significantly shorter than that of axial images for each reader ($p < 0.01$). Using coronal imaging to complement axial imaging 12 additional stones were detected and 23 were diagnosed with increased confidence by reader 1, while an additional 15 were detected and 8 were diagnosed with increased confidence by reader 2. The mean size of stones detected with coronal reformations alone was significantly smaller than that of the total stones. Excellent interobserver agreement was noted for coronal reformations and axial images (κ coefficient: 0.91 and 0.904, respectively).

Conclusions: Review of automated coronal reformations allows equally accurate and more rapid detection of urinary stones compared with axial images alone. In addition, coronal reformation of 64-detector computerized tomography adds value when used in conjunction with axial data sets.

Key Words: tomography, emission computed; kidney; ureter; calculi; diagnosis

Unenhanced CT has evolved as the imaging modality of choice for detecting urolithiasis in recent years.[1–6] The contributions of unenhanced CT include the prompt provision of diagnosis, high diagnostic accuracy, avoidance of iodine containing contrast material, capacity to identify alternative diagnoses and favorable economic impact on patient treatment.[7–9]

With the development of MDCT the radiological evaluation of patients with urological disease has evolved further. With 16-detector row CT the voxels of image raw data may be less than 1 mm and almost isotropic, which suggests that reformations in any desired plane would be similar in spatial resolution to those in the transverse plane.[10–12] The recent deployment of 64-MDCT offers still higher temporal and spatial resolution than that of 16-detector row CT.[13] In addition, reformations in any specified plane can be generated at the CT console at the time of scanning. High resolution coronal reformations are now routinely acquired virtually in real time at all abdominal examinations performed on a 64-MDCT scanner. Since the urinary tract is oriented in the coronal plane, we performed this study to assess the value of coronal reformations from the voxel data set obtained by 64-MDCT for the diagnosis of urinary stone disease.

MATERIALS AND METHODS

The institutional review board approved the study design and review of patient data for this retrospective analysis. Signed consent for data analysis was waived by the institutional review board.

Patients

From December 2005 to May 2006, 132 consecutive patients presented to our emergency department with acute flank pain and subsequently underwent unenhanced 16 or 64-MDCT for the suspicion of urolithiasis. We reviewed the institutional computerized clinical and radiological databases and included 72 patients in our study population. These patients were diagnosed with urolithiasis and studied on a 64-MDCT scanner.

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Study received institutional review board approval.

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Image Acquisition

Unenhanced CT was performed using a LightSpeed® VCT 64-MDCT scanner. The imaging protocol included section thickness 0.625 mm for a detector configuration of 64 × 0.625 mm, rotation time 0.5 second, pitch 0.984, table feed, 39.38 mm per rotation, tube voltage 140 kVp and effective tube current-time product 215 mA. The mean ± SD CT dose index was 16.77 ± 8.80 mGy. Scan length was adapted to the length of the patient abdomen and pelvis. The imaging noise index was between 32 and 35. The noise index value, which is a term specific to LightSpeed manufacturer products, is defined as the SD in the central region of the image obtained from scanning a uniform water phantom. A lower noise index implies less noise on images but a higher radiation dose.[14] Imaging parameters in our study indicated a lower radiation dose per examination compared to that of other diagnostic CT examinations, which have an effective tube current-time product of 80 to 400 mA and a noise index of 20 or less.[14]

Axial and coronal reconstructions were created in an automated mode on the Xtream™ scanner console system. A standard convolution kernel and a 512 × 512 matrix were used. Axial images were reconstructed using a 2.5 mm slice thickness. Coronal reformations used 3.0 mm and they were transferred as 2 separate series.

Image Interpretation

Two readers (DVS and CSL) with 13 and 8 years of experience with abdominal CT, respectively, who were blinded to the diagnosis reviewed all CT images independently. Interpretation included 2 sessions. At session 1 each reader interpreted coronal imaging alone to determine the location and size of urolithiasis. The location of stone on the right or left side was determined by organ level. Thus, the renal stone was coded as upper, middle, lower calices and renal pelvis. In ureteral stone cases a location indicating upper, middle, lower ureter or UVJ was determined. The size of each stone was determined by the maximal diameter shown on coronal imaging. In cases of multiple renal stones, ie more than 5, only the smallest stone was recorded. Each reader was asked to determine whether the image quality of coronal reformation in each patient was sufficient for diagnosis. For each visualized stone the confidence level of diagnosis was determined by each reader according to a 5-point scale of 5—very high, 4—high, 3—medium, 2—low and 1—very low confidence. The required time for interpretation was recorded using a stopwatch.

At session 2 each reader reviewed axial images alone. The definition of stone location was the same as that at session 1. Size measurement was based on axial imaging. Reader confidence and required time were also recorded. Readers were allowed to adjust the window setting of images to facilitate interpretation.

To evaluate the effect of combined axial and coronal imaging the coronal images of each patient were presented again immediately after the interpretation of axial images. The readers were asked to record whether the complementary coronal images changed the diagnosis of stone burden or confidence level of diagnosis.

At each session a detected stone was considered the final result of each reader only when reader confidence was 4 or 5. There was a 2-week interval between these 2 interpretation sessions for each reader to minimize recall bias. In each patient the number of slices of coronal and axial images for covering the entire kidneys, ureters and bladder were recorded.

Reference Standard

The reference standard was determined by consensus of the same 2 readers who were involved in the mentioned interpretation sessions. The diagnosis of urolithiasis was based on unequivocal evidence of calcium density, which was not in the location of vessel wall or renal parenchyma, on axial as well as on coronal images. Clinical information on patient symptoms, medical records, including episodes of hematuria or pain, treatment for this and other episodes, and patient outcomes were also available.[15] The size of each stone in this consensus reading was determined by the maximal diameter on axial images as the standard of practice.

Analysis of Stone Detection

The results obtained from coronal and axial imaging interpretations by each reader were compared to the reference standard to determine the detection rate of each image set for urolithiasis. This analysis was performed per stone level except in cases of multiple renal stones, when there were more than 5 renal stones in 1 kidney. In cases of multiple renal stones the coronal or axial images were considered to correctly detect the renal stones if the imaging set detected more than 5 renal stones in a single kidney and we counted these multiple renal stones as a single lesion.

The detection of 3 mm or less stones was then analyzed separately to determine the detection rate of axial and coronal images for small urinary stones. Thereafter the detection of ureteral stones was also analyzed separately.

To determine the sensitivity and specificity of coronal and axial images the presence or absence of urolithiasis in each patient was recorded per organ level, ie right kidney, left kidney, right ureter, left ureter and bladder. Only stones diagnosed with a reader confidence of 4 or 5 were considered positive findings for either reader. Interobserver variation was also analyzed based on agreements of the 2 readers with respect to urolithiasis at the mentioned 5 locations. The detection rates of urinary stones per patient level with coronal and axial images were also calculated.

Statistical Analysis

Statistical analysis was performed with SPSS®, version 10.0. Continuous variables are expressed as the mean ± SD and the t test was used for comparison. The 2-tailed Fisher's exact test was used for analysis of nominal variables. Any discrepancies between coronal or axial imaging findings and the reference standard were considered false-positive or false-negative results to calculate sensitivity and specificity, and the McNemar test was used for comparison. Statistical significance was considered at a threshold value of $p = 0.05$. Nonweighted binary κ statistics were used to quantify interobserver agreements with respect to the presence of urolithiasis per location.

RESULTS

Reference Standard

The study population consisted of 26 women and 46 men with a mean age of 48.9 ± 16.2 years. Table 1 shows the