Usefulness of Low-dose Nonenhanced Computed Tomography With Iterative Reconstruction for Evaluation of Urolithiasis: Diagnostic Performance and Agreement between the Urologist and the Radiologist

Jong Kyou Kwon, In Ho Chang, Young Tae Moon, Jong Beum Lee, Hyun Jeong Park, and Sung Bin Park

OBJECTIVE To evaluate the efficacy of low-dose nonenhanced computed tomography (LDCT) with iterative reconstruction (IR) technique for urologists to detect urolithiasis by comparing diagnostic performance and interobserver agreement between the urologist and the uroradiologist.

PATIENTS AND METHODS We evaluated the 116 patients with urinary stones (n = 197) using both conventional-dose nonenhanced computed tomography (CT) using filtered back projection (CDCT-FBP) and LDCT-IR. Scans were interpreted for stone characteristics, objective image noise, and subjective image assessment. Diagnostic performance and interobserver agreement of LDCT-IR were assessed between 1 urologist and 1 radiologist.

RESULTS There were no significant differences in all stones. The average effective dose (mSV) in the all size groups was 5.92 (CDCT-FBP) and 1.39 (LDCT-IR), respectively (P <.001). The average effective dose reduction rate was 76.6%, allowing minimal additional radiation exposure from simultaneous CT. Objective image noise was higher in LDCT-IR (20.0-26.2; P <.01), but there was no significant difference in the Hounsfield unit between both CT protocols (52.3 and 56.7; P = .103). There were no cases of any unacceptable images in subjective image assessment. The sensitivity and specificity of LDCT-IR were 99.1%-100.0% with a diagnostic accuracy of 99.1%-100% for stones ≥3 mm. Diagnostic performance was similar between the urologist and the radiologist. Interobserver agreement of LDCT-IR between the 2 reviewers was high with kappa values (0.901-1.000).

CONCLUSION LDCT-IR provided an excellent diagnostic performance and interobserver agreement between the urologist and the uroradiologist, reducing radiation exposure significantly; in real settings, the urologist should consider replacing LDCT-IR as the standard examination for detecting urolithiasis. UROLOGY 85: 531−538, 2015.

Nonenhanced computed tomography (CT) is now the imaging modality of choice in the urinary stone disease with sensitivity and specificity of 94%-100% and 97%, respectively.[1] However, the patients are usually exposed to about a 3-5 times higher radiation dose than intravenous urography.[2,3] Exposure to ionizing radiation can result in carcinogenesis, which is a stochastic and unpredictable effect even with a single typical abdominal CT.[4-6] Urolithiasis may be increasing with a lifetime incidence of 5%-10% in the United States, and about 75% of patients with a single stone episode have experienced a recurrence during their lifetime.[7,8] Because the majority of patients are relatively young adults often requiring multiple CT examinations for treatment of urolithiasis, radiation exposure is of particular concern especially in this population. Reduction of the radiation dose is now essential for minimizing the concerns about CT for both the patient and the physician. Efforts have already been made to achieve radiation dose reduction using low-dose nonenhanced CT (LDCT) for assessment of urinary stones,[9-11] but a

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From the Department of Urology, Chung-Ang University Hospital, Chung-Ang University College of Medicine, Seoul, Republic of Korea; and the Department of Radiology, Chung-Ang University Hospital, Chung-Ang University College of Medicine, Seoul, Republic of Korea

Address correspondence to: Sung Bin Park, M.D., Ph.D., Department of Radiology, Chung-Ang University Hospital, 102, Heukseok-ro, Dongjak-gu, Seoul 156-755, Republic of Korea. E-mail: pksungbin@paran.com
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reduction in radiation dose at the cost of increased image noise compared with conventional-dose nonenhanced CT (CDCT) is the major obstacle to widespread routine use of LDCT. Image noise can affect the diagnostic performance and lead to misdiagnosis resulting in unfavorable clinical outcomes for urologists who are actively treating stone disease but are unfamiliar with these coarse image settings.

The recent advances in imaging technology have greatly improved the chances to decrease image noise accompanied by radiation dose reduction in CT examination. One such advancement, a hybrid iterative reconstruction (IR) algorithm (iDose; Philips Healthcare),[12] which is one of the IR technique, consists of the noise-reducing components as follows: an iterative maximum likelihood—type sinogram restoration method based on the Poisson noise distribution and an iteratively decrease of the uncorrelated noise by using local structure model fitting on image data. When performed, it allows performers to adjust the level of the image noise by inputting IR level. Although there are some limitations in choosing CT setting (kVs and mAs) in real clinical settings, theoretically, the larger the IR level is, the larger the noise reduction is, allowing performers to prospectively decrease the radiation dose at the time of the examination. IR technique has shown promising prospects with regard to dose reduction compared with standard filtered back projection (FBP) with reduction in image noise in the radiologic field focusing on the diagnostic performance of the radiologist.[3,13,14] However, there have been no attempts to validate the diagnostic performance for the urologist.

In this study, we prospectively determined the diagnostic performance of LDCT with IR (LDCT-IR) for detection of urinary stones by using CDCT with FBP (CDCT-FBP) as the reference standard and investigated interobserver agreement of LDCT-IR images between the urologist and the uroradiologist by comparing the direct interpretation for reconstructed images.

PATIENTS AND METHODS

Institutional Review Board

This study was approved by the Institutional Review Board of the Chung-Ang University Hospital (Seoul, South Korea), and an informed consent was obtained from all the patients after providing the study details, including information on the additional radiation dose.

Patient Population and Study Design

Between December 2012 and February 2013, 249 consecutive patients who underwent CT examination for suspected acute renal colic were found to be eligible for participation in the study. Eligibility criteria included no possibility of pregnancy, no history of surgery using an implantation device that can cause any imaging artifacts, no urinary tract abnormalities, and no history of a recently diagnosed malignant disease. Two patients with bladder stones, 2 patients diagnosed with other diseases, and 6 patients with an irregular stone shape (ie, steinstrasse) were excluded, and 123 patients refused LDCT-IR. Finally, 197 stone lesions in 116 patients (75 men and 41 women; mean age, 48.9 ± 16.2 years) were enrolled into this study, and the patients underwent CDCT-FBP followed by LDCT-IR immediately.

A consensus panel including 4 experienced reviewers (2 radiologists and 2 urologists) was formed to establish the reference diagnosis for investigation of diagnostic performance and statistical accuracy based on CDCT-FBP.

CT Protocol and Data Reconstruction

CDCT (a tube voltage of 120 kV and tube current—time product of 150 mAs) followed by LDCT (a tube voltage of 100 kV and tube current—time product was 60 mAs) for detection of urinary stones was performed with a 256-section CT scanner (iCT; Philips Medical Systems, The Netherlands). Automatic exposure control (DoseRight; Philips Healthcare) according to the patient's body mass index (BMI) was used for all scans. IR technique (iDose reconstruction technique, level 5; Philips Healthcare) was applied for reconstruction of LDCT images. Coronal images were obtained by performing 1-mm thin-section CT scans and 3-dimensional reconstruction. All the image data sets were then transmitted to the picture archiving and communication system (PACS; Marosis M-view software; Marotech, Seoul, South Korea) for image interpretation. Figure 1 indicates the difference in the image quality of CDCT-FBP and the image quality of LDCT before and after IR.

Radiation Dose

The actual radiation dose was directly generated from the CT scanner after automatically adjusted according to the patients' body size, and it was recorded in terms of the dose-length product (DLP). DLP converted into the effective dose (ED; in mSv) by multiplying the conversion coefficient 0.015 mSv/mGy/cm. Reduction rate of both DLP and ED was compared between the 2 scans.

Objective Image Noise and Subjective Image Assessment

Objective image noise measurement and subjective image assessment were performed by 2 radiologists who were on the consensus panel. Objective image noise was measured as the standard deviation of the mean CT number from PACS, which was measured by placing a region of interest of 80-110 mm^2 in the right lobe of the liver, the spleen, and the psoas muscle from PACS by manual process.

Subjective image assessment of each CT scan was independently rated by 2 radiologists who were on the consensus panel and were blinded to the detailed technical scanning parameters used. All the images were displayed in a random fashion, and image quality, image noise, and confidence level were rated on the 3-point and 5-point scales.[15] The reviewers performed a comprehensive review of each scan based on the scores of image quality, image noise, and confidence level and classified the subjective image assessment as acceptable and unacceptable image for the detection of urinary stones.

CT Data Analysis and Interpretation

All the CT data images were anonymized and randomized before analysis and interpretation, and then, the same stone was compared on both scans. Interpretations of the 2 scans were performed prospectively and independently with respect to stone characteristics (size, volume, location, Hounsfield unit [HU], and skin-to-stone distance [SSD]). LDCT-IR images