Original Investigation

Sub-solid Nodule Detection Performance on Reduced-dose Computed Tomography with Iterative Reduction: Comparison Between 20 mA (7 mAs) and 120 mA (42 mAs) Regarding Nodular Size and Characteristics and Association with Size-specific Dose Estimate

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Abbreviations and Acronyms

SSNDP sub-solid nodule detection performance

CT computed tomography

AIDR 3D Adaptive Iterative Dose Reduction using Three Dimensional Processing

SSDE size-specific dose estimate

Rationale and Objectives: This study aimed to compare sub-solid nodule detection performances (SSNDP) on chest computed tomography (CT) with Adaptive Iterative Dose Reduction using Three Dimensional Processing (AIDR 3D) between 7 mAs (0.21 mSv) and 42 mAs (1.28 mSv) in total and in subgroups classified by nodular size, characteristics, and location, and analyze the association of SSNDP with size-specific dose estimate (SSDE).

Materials and Methods: As part of the Area-detector Computed Tomography for the Investigation of Thoracic Diseases Study, a Japanese multicenter research project, 68 subjects underwent chest CT with 120 kV, 0.35 seconds per rotation, and three tube currents: 240 mA (84 mAs), 120 mA (42 mAs), and 20 mA (7 mAs). The research committee of the study project outlined and approved our study protocols. The institutional review board of each institution approved this study. Axial 2-mm-thick CT images were reconstructed using AIDR 3D. Standard reference was determined by CT images at 84 mAs. Four radiologists recorded SSN presence by continuously distributed rating on CT at 7 mAs and 42 mAs. Receiver operating characteristic analysis was used to evaluate SSNDP at both doses in total and in subgroups classified by nodular longest diameter (LD) (≥5 mm), characteristics

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(pure and part-solid), and locations (ventral, intermediate, or dorsal; central or peripheral; and upper, middle, or lower). Detection sensitivity was compared among five groups of SSNs classified based on particular SSDE to nodule on CT with AIDR 3D at 7 mAs.

Results: Twenty-two part-solid and 86 pure SSNs were identified. For larger SSNs (LD ≥ 5 mm) as well as subgroups classified by nodular locations and part-solid nodules, SSNDP was similar in both methods (area under the receiver operating characteristics curve: 0.96 ± 0.02 in CT at 7 mAs and 0.97 ± 0.01 in CT at 42 mAs), with acceptable interobserver agreements in five locations. For larger SSNs (LD ≥ 5 mm), on CT at 42 mAs, no significant differences in detection sensitivity were found among the five groups classified by SSDE, whereas on CT with 7 mAs, four groups with SSDE of 0.65 or higher were superior in detection sensitivity to the other group, with SSDE less than 0.65 mGy.

Conclusions: For SSNs with 5 mm or more in cases with normal range of body habitus, CT at 7 mAs was demonstrated to have comparable SSNDP to CT at 42 mAs regardless of nodular location and characteristics, and SSDE higher than 0.65 mGy is desirable to obtain sufficient SSNDP.

Key Words: Reduced-dose scanning; adaptive iterative dose reduction; sub-solid nodule; size-specific dose estimate; image noise; multicenter study; computed tomography; diagnostic performance.

ROC
receiver operating characteristics

LD
longest diameter

MBIR
model-based iterative reconstruction

IR
iterative reconstruction

SOR
standard of reference

CTDIvol
CT dose index volumes

GGN
ground-glass nodule

ROI
region of interest

AUC
area under the ROC curve

INTRODUCTION

Persistent sub-solid nodules (SSNs) can be a manifestation of pulmonary malignancies at an early stage and should be followed up at least 12 months later with a chest computed tomography (CT) from initial detection in cases with the diameter of 5 mm or more according to the management guideline by the Fleischner Society (1). However, carcinogenesis probability is higher proportionally with effective radiation dose, and further dose reduction with maintenance of image quality would be desirable (2,3).

Considerably reduced dose CT with comparable or slightly higher dose to chest X-ray using model-based iterative reconstruction (MBIR) (0.16–0.2 mSv) demonstrated the SSN detection performance comparable to reduced-dose CT with iterative reconstruction (IR) (0.92 mSv) or standard dose CT (11.2 mSv) (4,5). However, only relatively larger SSNs in small number were analyzed in these studies. Characteristics assessment of SSNs is clinically crucial because those with more solid-type components are associated with poorer prognosis (6–12). Subgroup analysis based on SSN characteristics was also not performed in these studies. In both pulmonary apical and paravertebral regions due to relative photon deficiency associated with larger body sections, nodular detectability on considerably reduced dose CT images without IR was reported to be inferior to that on CT images under a higher radiation dose (13). This disadvantage could be overcome by applying IR algorithm on CT images with considerably reduced dose. General positive impact of IR on nodule detection mainly due to noise reduction has already been demonstrated in many past studies. On the other hand, size-specific dose estimate (SSDE) corresponding to an individual image plane has been recently introduced as one of the more practicable dose adjustments on body cross sections (14–17), and SSDE in the transaxial plane including SSN can vary among nodular location even in an individual patient and may have an association with SSN detection performance. To the best of our knowledge, no past assessment in terms of the association of these background factors as described previously with SSN detection performance on considerably reduced dose CT image using iterative reconstruction has been performed.

The purpose of this study is to compare SSN detection performance on chest CT with Adaptive Iterative Dose Reduction using Three Dimensional Processing (AIDR 3D) between 20 mA and 120 mA in the total study population and in subgroups classified by the nodular longest diameter (LD; >5 mm), characteristics (part-solid, pure), and eight locations partially overlapped with one another (ventral, intermediate, or dorsal; central or peripheral; and upper, middle, or lower), and assess the association of particular SSDE to SSN with SSN detection performance.

MATERIALS AND METHODS

This study was conducted as part of the Area-detector Computed Tomography for the Investigation of Thoracic Diseases Study, an ongoing multicenter research project in Japan. The research committee of the study project outlined and approved our study protocols. The institutional review board of each institution approved this study, and written informed consent was obtained from all the participants.

Patients' Populations

Among 112 subjects who were initially enrolled in our previous research between December 2012 and March 2013 at six institutions for the assessment of detection performance for both pulmonary solid and SSNs (18), 28 patients with SSNs were identified after reviewing the CT images of all the