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Hybrid Type iterative reconstruction method vs. filter back projection method: Capability for radiation dose reduction and perfusion assessment on dynamic first-pass contrast-enhanced perfusion chest area-detector CT

Yoshiharu Ohno (MD PhD)[a,b,*], Hisanobu Koyama (MD PhD)[c], Yasuko Fujisawa (BS)[d], Takeshi Yoshikawa (MD PhD)[a,b], Hiroyasu Inokawa (BS)[d], Naoki Sugihara (MEng)[d], Shinichiro Seki (MD PhD)[c], Kazuro Sugimura (MD)[c]

[a] Division of Functional and Diagnostic Imaging Research, Department of Radiology, Kobe University Graduate School of Medicine, Kobe, Hyogo, Japan
[b] Advanced Biomedical Imaging Research Center, Kobe University Graduate School of Medicine, Kobe, Hyogo, Japan
[c] Division of Radiology, Department of Radiology, Kobe University Graduate School of Medicine, Kobe, Hyogo, Japan
[d] Toshiba Medical Systems Corporation, Otawara, Tochigi, Japan

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ABSTRACT

Purpose: To directly compare the capability of hybrid-type iterative reconstruction (i.e., adaptive iterative dose reduction using 3D processing: AIDR 3D) and filter back projection (FBP) for radiation dose reduction during dynamic contrast-enhanced (CE-) perfusion area-detector CT (ADCT) for lung and nodule perfusion assessment.

Materials and methods: Thirty-six patients with lung cancers who underwent perfusion ADCT (SD-ADCT) at 120 mA and were enrolled in this study. ADCT data at 80 mA (reduced-dose ADCT: RD-ADCT), 60 mA (low-dose ADCT: LD-ADCT) and 40 mA (very low-dose ADCT: VLD-ADCT) were computationally simulated using SD-ADCT data, and reconstructed with and without AIDR 3D. Image noise and lung and nodule perfusion parameters were evaluated using ROI measurements. To determine the utility of AIDR 3D for dose reduction, image noise was compared between each protocol with and without AIDR 3D by means of the *t*-test. Correlations and limits of agreement for parameters obtained with SD-ADCT and other protocols were also evaluated.

Results: Image noise of all protocols with AIDR 3D was significantly lower than that of LD-ADCT and VLD-ADCT without AIDR 3D ($p < 0.05$). Significant correlations for image noise between SD-ADCT and all protocols with AIDR 3D ($0.45 \leq r \leq 0.99$, $p < 0.0001$) were equal to or better than that without AIDR 3D ($0.28 \leq r \leq 0.99$, $p < 0.0001$). The limits of agreement for perfusion parameters with AIDR 3D were smaller than those without AIDR 3D for each tube current.

Conclusion: AIDR 3D is more effective than FBP for dose reduction of perfusion ADCT while maintaining image quality and reducing measurement errors.

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1. Introduction

Qualitative and quantitative assessments of pulmonary perfusion as well as pulmonary nodule perfusion performed by using dynamic contrast-enhanced (CE-) perfusion CT using electron-beam and multi-detector row CT might also be useful for quantitative perfusion assessment within lung parenchyma and pulmonary nodules or mass for a variety of clinical purposes [1–6]. However, such assessments have not been in wide clinical use until quite recently.

Since the introduction of a 320-detector row CT system with an area detector (ADCT) for clinical use, it has been suggested that quantitative assessment of nodule perfusion by means of dynamic first-pass CE-perfusion CT using ADCT and a few mathematical models can be more specific and accurate than FDG-PET/CT for differentiation of malignant from benign nodules, and for differentiation of nodules requiring further intervention and treatment

* Corresponding author at: Division of Functional and Diagnostic Imaging Research, Department of Radiology, Kobe University Graduate School of Medicine, Kobe, Japan, 7-5-2 Kusunoki-cho, Chuo-ku, Kobe, Hyogo, 650-0017, Japan. Fax: +81 78 382 6129.
E-mail addresses: yosirad@med.kobe-u.ac.jp, yoshiharuohno@aol.com, yosirad@kobe-u.ac.jp (Y. Ohno).

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from those requiring only follow-up examination [7–9]. In addition, this technique may be at least as effective as dynamic first-pass CE-perfusion MR imaging with ultra-short TE [9], and easier to use in routine clinical practice. However, one of the major drawbacks of this technique is the associated ionizing radiation dose, and radiation dose would be better to decrease as low as possible [1–9].

Recent advancements in central processing units and enhanced computer performance have made it possible to use iterative reconstruction algorithms in routine clinical practice. Although the standard FBP algorithm is based on several fundamental assumptions about CT geometry and is a compromise between reconstruction speed and image noise, iterative reconstruction algorithms are based on different assumptions about CT geometry combined with multiple iterations of reconstruction, and may thus result in less image noise from raw data [10–16]. Although a few investigators have suggested the model-based iterative reconstruction technique is more effective, one of the drawbacks of this method is the longer reconstruction time [12–14]. To overcome

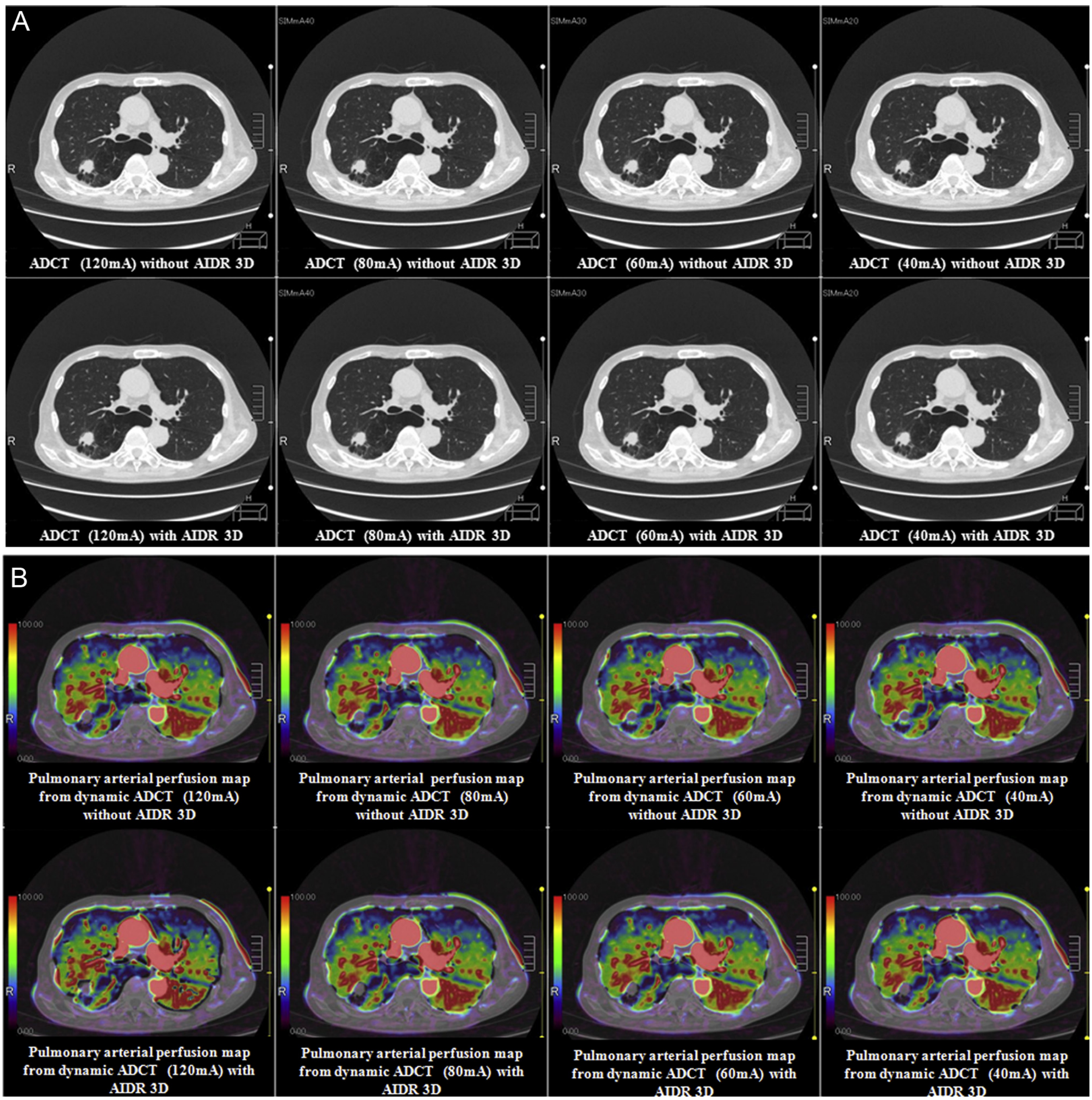

Fig. 1. 72-year-old male patient with invasive adenocarcinoma in the right lower lobe.
(From A to G: SD-ADCT, RD-ADCT, LD-ADCT and VLD-AD-CT reconstructed with and without AIDR 3D, pulmonary arterial perfusion maps derived from SD-ADCT, RD-ADCT, LD-ADCT and VLD-AD-CT data obtained with and without AIDR 3D, systemic arterial perfusion maps derived from SD-ADCT, RD-ADCT, LD-ADCT and VLD-AD-CT data obtained with and without AIDR 3D, total perfusion maps derived from SD-ADCT, RD-ADCT, LD-ADCT and VLD-AD-CT data obtained with and without AIDR 3D, perfusion maps derived from SD-ADCT, RD-ADCT, LD-ADCT and VLD-AD-CT data obtained with and without AIDR 3D, extraction fraction maps derived from SD-ADCT, RD-ADCT, LD-ADCT and VLD-AD-CT data obtained with and without AIDR 3D, blood volume maps derived from SD-ADCT, RD-ADCT, LD-ADCT and VLD-AD-CT data obtained with and without AIDR 3D). Although image noises slightly increased from SD-ADCT, RD-ADCT, LD-ADCT and VLD-ADCT with and without AIDR 3D, all perfusion maps except the blood volume map showed only minor differences among all simulated dose data for lung parenchyma and nodules obtained with and without AIDR 3D. Regional blood volumes within lung parenchyma and nodules shown by data obtained with perfusion ADCT without AIDR 3D changed more in accordance with radiation dose reduction than did those shown by data obtained with perfusion ADCT with AIDR 3D.

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