Clinical Imaging 38 (2014) 104–108

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: http://www.clinicalimaging.org

Combined multi-kernel chest computed tomography images optimized for depicting both lung and soft tissue

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ARTICLE INFO

Article history:
Received 14 June 2013
Received in revised form 21 October 2013
Accepted 14 November 2013

Keywords:
Chest computed tomography
Window settings
Reconstruction kernel
Combined multi-kernel

ABSTRACT

Purpose: To evaluate the quality of our improved multi-kernel chest computed tomography (CT) images.
Methods: A random sample of 50 normal patients was retrospectively selected from those who underwent chest CT scans between January 2010 and July 2010. Normal lung structures were divided into six categories, and two radiologists independently compared with lung images.
Results: The improved multi-kernel images were displayed identically to soft tissue images on soft tissue window settings and were evaluated as equal to lung images on lung window settings.
Conclusions: This improved multi-kernel technique required fewer stored images and simplified examinations of chest CT.

1. Introduction

Computed tomography (CT) images are reconstructed using several kernels to evaluate tissues with both high and low contrast. In chest CT imaging, high-pass filter kernels, which preserve higher spatial frequencies and increase noise, are used to depict high-contrast lung images. Conversely, low-pass filter kernels, which decrease higher spatial frequencies and noise, are used to depict low-contrast soft tissue images. Although two separate image sets are generally reconstructed at each level, the window settings of those image sets are distinctly different.

To evaluate both lung and soft tissues with change in window settings in an image set, Strub et al. [1] developed a hybrid reconstruction kernel technique, which is optimized to evaluate both lung and soft tissues, thus simplifying examinations and decreasing the number of images that need to be stored. Hybrid reconstruction kernel images have been reported, in which pixels of<−150 Hounsfield unit (HU) or >150 HU in soft tissue images (low-pass kernel-reconstructed) were substituted with the corresponding pixels from lung images (high-pass kernel-reconstructed). Although Strub et al. reported that these hybrid reconstruction kernel images were comparable to soft tissue images in an evaluation using the soft tissue window settings (window width, 350 HU; window level, 40 HU), artifacts similar to calcification appeared in the lung fields (Fig. 1C). The cause of these artifacts was overshooting, which occurred along the high CT contrast edges in the lung images (Fig. 1B). In brief, pixels of<−150 HU in soft tissue images and in which overshoots have occurred in lung images demonstrated far greater values than −150 HU and displayed white areas (similar to calcification) in hybrid reconstruction kernel images. On the other hand, pixels of >150 HU in the soft tissue images and in which undershoots have occurred in the lung images caused black dot artifacts in the bone regions using the soft tissue window settings (Fig. 1B, C).

Therefore, the purpose of the present study was two-fold: to decrease the artifacts on soft tissue window settings in the previous hybrid reconstruction kernel technique by improving the image processing algorithm and to evaluate the image quality compared to that of both lung and soft tissue images.

2. Materials and methods

2.1. Patients

A random sample of 50 normal patients who underwent chest CT scans between January 2010 and July 2010 was retrospectively selected

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0899-7071/$ – see front matter
http://dx.doi.org/10.1016/j.clinimag.2013.11.009

in this study (25 men and 25 women; age, 34–83years; mean age, 63 years). Our institutional review board approved this retrospective study and waived the need for informed patient consent.

2.2. Data acquisition

All examinations were performed using a 64-row multidetector CT scanner (Aquilion 64, Toshiba Medical Systems, Tokyo, Japan) during a deep inspiratory breath hold. The technical parameters were as follows: peak tube voltage, 120 kV; tube current, automatic exposure control (Volume-EC, Toshiba Medical Systems) with noise index 7.5; gantry rotation period, 0.5 s; slice collimation, 0.5 mm×64; and pitch factor, 1.17. The image sets were reconstructed at the same thickness (7 mm gapless), field of view (350 mm), and separate reconstruction kernels (lung, FC52; soft tissue, FC13).

2.3. Image processing

Our improved combined multi-kernel chest CT images were generated in a way that pixels of ≤−150 HU in soft tissue images, if also ≤−150 HU in lung images, were substituted with the corresponding pixels from lung images. Because higher spatial frequencies are not generally required for pixels of >150 HU using the lung and soft tissue window settings, pixels of >150 HU in soft tissue images were not substituted. The custom software was developed using Microsoft Visual C#.

2.4. Image evaluation

Image quality evaluations were independently performed by two radiologists (with 12 and 23 years of experience) using a 3-megapixel, 20.8-inch, monochrome, liquid crystal, display monitor. Normal lung structures were divided into six categories: central vessels, peripheral vessels, major and minor fissures, bronchi, bronchioles, and pulmonary parenchyma. The quality of the improved multi-kernel images was compared with that of lung images in each category and was evaluated as equal or inferior. Both images were displayed simultaneously at the same level on lung window settings (window width, 1500 HU; window level, −600 HU) using custom software.

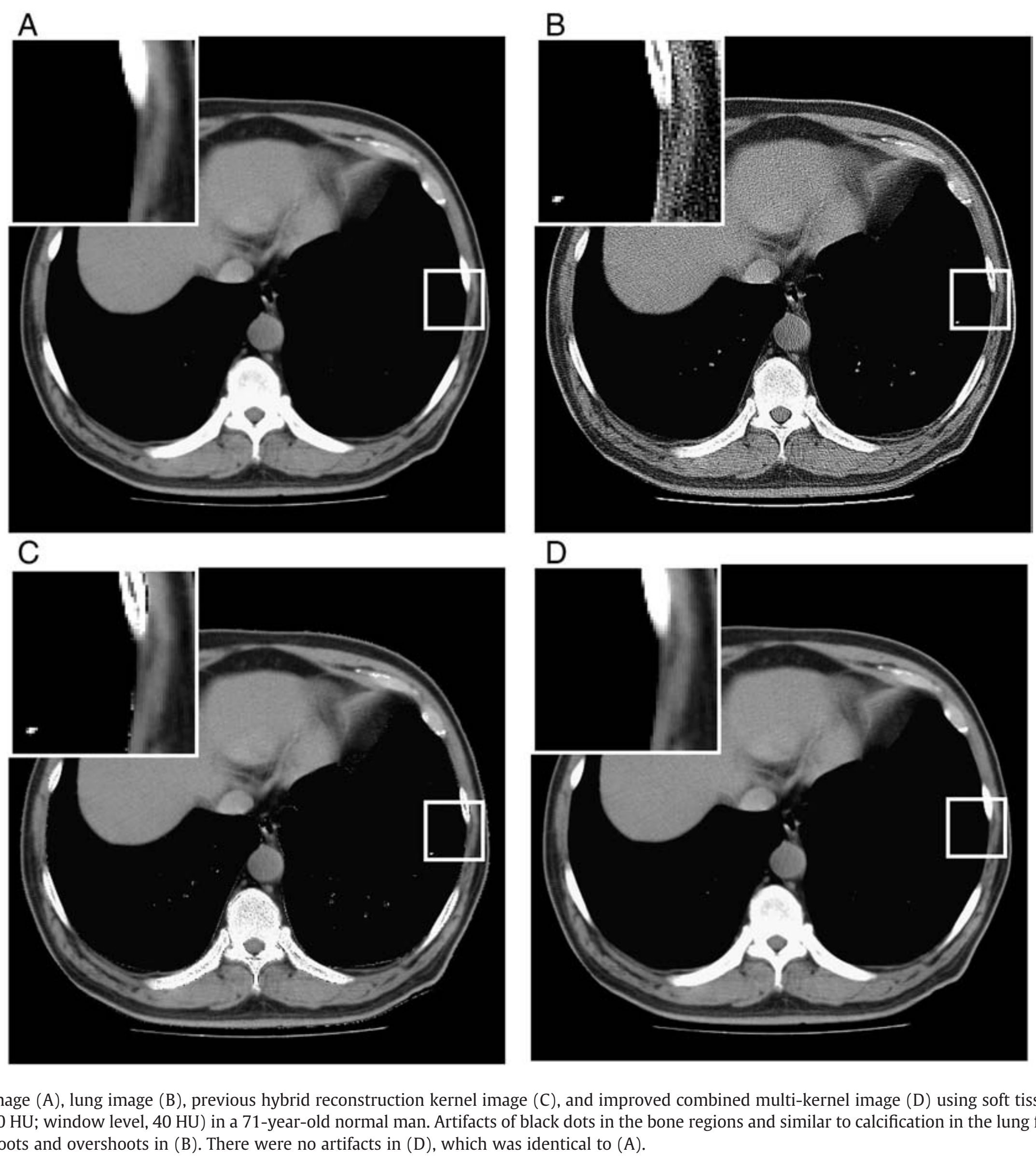

Fig. 1. Soft tissue image (A), lung image (B), previous hybrid reconstruction kernel image (C), and improved combined multi-kernel image (D) using soft tissue window settings (window width, 350 HU; window level, 40 HU) in a 71-year-old normal man. Artifacts of black dots in the bone regions and similar to calcification in the lung field appeared in (C) because of undershoots and overshoots in (B). There were no artifacts in (D), which was identical to (A).