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The Effects of Radiation Dose and CT Manufacturer on Measurements of Lung Densitometry*

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Background: **To evaluate the effect of radiation dose and scanner manufacturer on quantitative CT scan measurements of lung morphology in smokers.**

Methods: **Low-dose and high-dose, inspiratory, multislice CT scans were obtained in 50 subjects at intervals of approximately 6 months (mean [± SD] interval, 0.5 ± 0.2 years). In another 30 subjects, multislice CT scans were acquired first using a GE LightSpeed Ultra (General Electric Healthcare; Milwaukee, WI), followed a mean time of 1.2 ± 0.4 years later by using a Siemens Sensation 16 scanner (Siemens Medical Solutions; Erlangen, Germany). Custom software was used to measure lung volume, mass, mean density, and the extent of emphysema using threshold cutoffs of −950, −910, and −856 Hounsfield units (HU) and the lowest 15th and 5th percentile points.**

Results: **The change in radiograph dose significantly affected measurements of emphysema assessed using mean lung density, threshold, or percentile methods. There were also interactions between dose and total lung volume for all of the measurements except the −950-HU threshold and the lowest fifth percentile point. These two emphysema measurements suggest that there was more emphysema found in the CT scans obtained using a lower radiograph dose. Only the mean lung density and −856-HU threshold showed significant effects between CT scanner manufacturers and interactions between total lung volume and scanner. All other measures of lung structure were not different between the two CT scanners.**

Conclusion: **CT scan measurements of very low density lung structures are significantly affected by radiation dose but are less sensitive to the lung volume. Image acquisition parameters including radiation dose, scanner type, and the subject's breath size should be standardized to estimate emphysema severity in longitudinal studies.** ***(CHEST 2007; 132:617–623)***

Key words: CT scan; emphysema; lung expansion; radiation dose

Abbreviations: %Emphysema = percentage of emphysema; HU = Hounsfield unit

Quantitative CT scanning has become a very popular method for quantifying the extent and severity of pulmonary emphysema.[1–3] Previous studies have shown that CT scan estimates of total lung volume, mass, mean lung density, and percentage of emphysema (%Emphysema) are reproducible[4–7] and are significantly correlated with both lung function test[8–11] and pathology findings.[12–18] Furthermore, two advantages of CT scan image analysis are that it allows the assessment of lung structure *in vivo* and is relatively easy to obtain in most centers. These are important features because it is now possible to investigate the pathogenesis of lung destruction and/or the effect of interventions on the disease process in large multicenter cohorts of subjects. Examples of these multicenter applications are the National Emphysema Treatment Trial[19] and the Lung Tissue Repository Consortium (Presented at the 2005 Annual Meeting of the Radiologic Society of North America) in the United States and the α_1-Antitrypsin Deficiency Network in Europe. Additionally, many centers are actively involved in the longitudinal follow-up of suspicious lung nodules in subjects who are susceptible to lung cancer. As these

subjects are also at risk for the development of emphysema, there is great interest in using these cohorts for more comprehensive studies of smoking-related lung disease.

However, before large-scale longitudinal studies are undertaken it is important to assess the possible effect that parameters such as scanner manufacturer, slice thickness, reconstruction algorithm, and lung volume control have on both image quality and comparability of quantitative CT scan data. Therefore, the purpose of this study was to evaluate the effect of CT radiation dose (radiograph tube current) and scanner manufacture on quantitative CT scan measurements of lung morphology in smokers with emphysema.

Materials and Methods

Subject Selection

Subjects for this study were selected from the British Columbia Cancer Agency Lung Health Study.[20] The study was approved by the clinical ethics review boards of the British Columbia Cancer Agency and the University of British Columbia. All subjects signed informed consent forms to allow their spirometry and CT scan images to be used for research. This study comprises a cohort of heavy smokers who have been screened for the presence of lung nodules using "low-dose" CT scans. If suspicious nodules are noted, the subjects receive follow-up "high-dose" CT scans for up to 2 years. At entry into the study, smoking status was documented and baseline spirometry data were collected using American Thoracic Society criteria. Subjects also underwent periodic spirometry testing over the next 2 years. Fifty consecutive subjects who had received a baseline low-dose CT scan and a high-dose follow-up CT scan and spirometry tests within 6 months of the CT scan dates were selected from this cohort to investigate the effect of radiation dose (*ie*, radiograph tube current) on CT scan measurements of lung structure. In addition, 30 consecutive subjects who underwent baseline CT scans using a General Electric scanner and follow-up CT scans using a Siemens scanner were selected to study the effect of CT scanner manufacturer on lung densitometry measurements. Subjects were not selected for the study on the basis of lung function or the presence and extent of emphysema. There were seven subjects who were involved in both studies.

CT Scan Technique

All CT scans were acquired in the volume-scan mode at suspended full inspiration without the use of IV contrast media while the subject was in the supine position, resulting in > 200 images per CT scan (range, 212 to 323 images). The low-dose CT scans were acquired using a GE Lightspeed Ultra multislice CT scanner (General Electric Healthcare; Milwaukee, WI). Image acquisition parameters were an x-ray tube potential of 120 kVp, a tube current of 80 to 100 mA (100 mA, 48 of 50 cases; 80 mA, 2 of 50 cases), 0.5-s gantry rotation time, pitch 1.35 (average effective mA, 30 mA), and 1.25-mm slice thickness; images were reconstructed using an intermediate spatial frequency reconstruction algorithm (*ie*, "standard"). The high-dose CT scans were acquired approximately 6 months after the low-dose scans (mean [$\pm$ SD] time, 0.5 ± 0.2 years) using the same GE scanner and image parameters with the exception of the tube current, which was set at 320 mA (average effective mA, $320 \times 0.5/1.35 = 118$ mA). In the second set of subjects, images were acquired first using the GE Lightspeed Ultra scanner, and the high-dose (average effective mA, $320 \times 0.5/1.35 = 118$ mA) protocol followed a mean time of 1.2 ± 0.4 years later with images acquired using a Siemens Sensation 16 multislice scanner (Siemens Medical Solutions; Erlangen, Germany). The Siemens protocol consisted of an x-ray tube potential of 120 kVp, a tube current of 250 mA, a rotation time of 0.5 s, and a pitch of 1.25 (average effective mA, $250 \times 0.5/1.25 = 100$ mA). Images were reconstructed using a slice thickness of 1 mm and an intermediate spatial frequency reconstruction algorithm ("b35f").

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