Introduction and Objective

- Lung cancer continues to be the leading cause of death from cancer among men and women in the United States, with 253,290 new cases and 158,770 deaths in 2018 alone (Siegel et al., 2018).
- Low dose-CT screening has been shown to reduce lung cancer mortality (National Lung Cancer Screening Research Team).
- The current low dose CT technique is limited by poor image quality.
- Iterative reconstruction techniques were introduced to improve image noise and improve quality.
- Adaptive statistical iterative reconstruction (ASIR-V) has been developed to achieve the balance of image quality and processing efficacy.
- CAD programs are significantly faster in detecting nodules, have high sensitivity, but also significant false positive rates for pulmonary nodules (Prakashini et al., 2016).
- The use of CAD programs for pulmonary nodule evaluation is expected to increase as lung screening becomes more commonplace with advances in dose reduction.

The purpose of this study is to investigate the impact of various CT scan parameters with ASIR-V on the semi-automated diameter and volume measurements of lung nodules using a CAD program.

Methods

A multipurpose chest phantom with and without added fat slabs (N1 “LUNGMAN”; Kyoto Kagaku) was used in our study to simulate chest CT imaging (Figure 1). The lungs of the multipurpose chest phantom were implanted with 8 simulated lung nodules of four sizes (5, 8, 10, and 12 mm) of two material types to mimic ground glass and solid nodules (~800 HU and 100 HU, respectively) at varying locations throughout the lung structure (Figure 2).

This study utilized a modern MDCT scanner that has hybrid iterative and model-based CT scan image reconstruction algorithm (ASIR-V). The phantoms were scanned using the following CT protocol: 80 mm Helical Plus, 0.9 pitch, 0.5 rotation, 0.625 mm, GE Revolution CT. Multiple series were acquired by varying tube current, voltage, and ASIR-V levels.

Nodule diameter and volume were recorded across scan parameters by using a semi-automated nodule detection module in CareRecon Aquarius workstation (San Mateo, Calif.). Most segmentation procedure of the lung nodule was done with a “single click” option with minimal manual modification to the nodule boundary. All 768 lung nodule image dataset (96 protocols x 8 nodules) were segmented using this procedure. The nodule dimensions provided by the phantom manufacturer regarded as the reference standard. Nodule dimensions obtained in our experiment were tabulated and compared to the reference standard to quantify the variance and impact of various scan parameters on nodule dimensions.

Results

One-way ANOVA test showed significant impact of current, nodule diameter, and nodule type in CAD diameter measurement (p < 0.0001). Voltage, ASIR-V level, and the presence of fat slabs did not significantly impact CAD diameter measurement (p = 0.4788, p = 0.8975, p = 0.1857, respectively). (Table 3)

Univariate regression analysis for systematic error in diameter measurement, we found that that error is negatively related to current (95% CI [−0.0000777, −0.0000935], p < 0.0001) and the presence of a solid nodule (95% CI [−0.0000803, −0.0000958], p < 0.0001). Additionally, we found that error was positively related to increasing nodule diameter 95% CI (0.0040322, 0.0064982), (p < 0.001) (Table 4).

Our phantom study suggests that ASIR-V technology has the advantage of providing significant radiation dose reduction in chest CT while maintaining pulmonary nodules quantification accuracy using CAD.

Conclusions

Our phantom study reinforces that the size and type of nodules, and to an extent mA, may have the strongest impact on the performance of a CAD software to produce results that are near to the truth. Other parameters such as kV and ASIR-V can be manipulated in all (both thin and obese) patients to reduce radiation dose and not adversely affect the performance of a CAD program.

The findings of this study points to a low radiation dose method of screening for lung cancer, allowing patients to get medical care earlier in their disease process and possibly reducing mortality from lung cancer.

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References