Comparing Edge-on-Silicon Photon-Counting CT and Energy-Integrating CT for the Diagnosis of Bronchitis: A Virtual Imaging Trial Study

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Purpose: To assess the quantitative benefits of deep silicon-based photon-counting CT (PCCT) in comparison to conventional energy-integrating CT (EICT) for airway measurements.

Methods: CT images of patients diagnosed with chronic obstructive pulmonary disease (COPD) were used to create a set of anthropomorphic-computational human phantoms (XCAT) with bronchitis. These phantoms represented different levels of bronchitis severity, indicated by the area of airway structures. The XCAT phantoms were virtually imaged using a validated CT simulator (DukeSim) that modeled the scanner-specific geometry of both an experimental edge-on-silicon PCCT scanner and a conventional EICT scanner (Revolution, GE Healthcare) at three different tube currents (100, 200, 350 mA), tube voltage of 120 kV, rotation time of 1 second, and a pitch of 1. CT sinograms were reconstructed using the vendor's toolkit with filtered back projection algorithm, standard and bone kernels, FOV of 500 mm, and matrix size of 512. Pi10 measurements were acquired by taking the square root of wall area around 10-mm perimeter airways. The percent difference between the Pi10 measurements from the ground-truth and CT images was used as a metric to evaluate the performance of two systems.

Results: On average, across all tube currents and kernels, the difference in Pi10 measurements between CT images and the ground-truth were 57.2% ± 18.0% for EICT and 41.7% ± 12.6% for PCCT. As tube current decreased from 350 to 100 mA and averaged over all kernels, PCCT demonstrated more accurate Pi10 measurements than EICT by 15.0%. For both systems, bone kernel was more effective in accurately quantifying bronchitis. Overall, PCCT provided better Pi10 measurements compared to EICT.

Conclusion: Across all protocols, PCCT showed better performance for airway measurements due to enhanced spatial resolution. This study demonstrated the potential benefits of deep Si-based PCCT over EICT for bronchitis quantifications in a virtual imaging trial.