Quantitative Imaging Biomarkers Alliance

Application for QIBA Round-2 Project Funding

Title of Proposal: **Impact of Dose Saving Protocols on Quantitative CT Biomarkers of COPD and Asthma**		
QIBA Committee/Subgroup: CT Modality/COPD-Asthma Subcommittee		
NIBIB Task Number(s) which this project addresses: Tasks 1, 2, and 3		
Project Coordinator or Lead Investigator Information:		
Last Name: Fain	First Name: Sean	Degree(s): Ph.D.
e-mail:	Tel #:	
Institution/Company: University of Wisconsin School of Medicine and Public Health		
Amount Requested:		

Please check the primary category for this proposal from among the following:

☒ 1. Identification of Technical Characteristics and Standards

- ☒ a. Creation and refinement of protocols for image acquisition, analysis, quality control, etc., for specific clinical utility
- ☒ b. Phantom development and testing
- ☐ c. Identification and assessment of intra-reader bias (1) and variance across scanners and centers
- ☑ d. Identification and assessment of inter-reader bias and variance across scanners and centers
- ☒ e. Other

☐ 2. Clinical Performance Groundwork

- ☐ a. Assessment of intra-reader sensitivity and specificity
- ☐ b. Assessment of inter-reader sensitivity and specificity
- ☐ c. Other

☐ 3. Clinical Efficacy Groundwork

- ☐ a. Assessment of correlation between new biomarker and 'accepted-as-standard' method
- ☐ b. Characterization of value in clinical trials
- ☐ c. Characterization of value in clinical practice
- ☐ d. Development/merger of databases from trials in support of qualification
- ☐ e. Other

☒ 4. Resources (money and/or people) committeed from other sources.

CT Scanners at University of Wisconsin Hospital and Clinics, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin; "COPD Gene" and "Severe Asthma Research Program (SARP)" Lung Phantom; Phantom Laboratory CATPHAN phantoms; CT scans acquired as part of ongoing NIH trials investigating longitudinal quantitative changes in the lungs of subjects with asthma.

Project Description

Longitudinal clinical research studies that depend on quantitative measures of CT (qCT) number and structures depend on stable and reproducible image fidelity in often young, radiation sensitive, populations. Quantitative image measures of CT number and structural dimensions in ongoing lung studies, such as parenchymal density and airway wall thickness, have been shown to vary substantially according to the CT scanner make and model due to factors that differentially affect image noise, artifacts, and other image quality parameters, such as low contrast detectability and MTF. Imaging at the lowest possible dose, while maintaining diagnostic accuracy, is important to reduce the patient's risks from radiation. While image noise is normally adversely affected by adjusting scan parameters to decrease radiation dose, there now exist methods that allow decreased dose with no significant effect on image quality. However, there are significant questions as to effects of these techniques on qCT measures. These dose reduction techniques include automatic exposure control (AEC) systems, such as Smart mA on the GE systems, which produce mA modulation in the Z and angular directions, and iterative reconstruction (IR) techniques such as ASIR (GE).

Additionally, the effects of simple dose reduction, with or without the use of the AEC and IR, on the qCT numbers for parenchyma and on bronchial airway measures can be investigated. This can be accomplished by conventional protocol optimization with validation using phantoms, but can also be extended and verified in simulations in actual clinical scans by the addition of random noise to the raw scan data. Increasing the helical pitch also can reduce the patient dose, but at a penalty of increased image noise. However, when varying the pitch, the mA and rotation time can be adjusted to keep the patient dose constant. The net result of varying pitch at constant dose can then be investigated.

We propose to use careful phantom design, starting with the COPD Gene Lung Phantom and extending these measurements in phantoms of our own design with a larger axial and radial cross-section to investigate the role of dose reduction techniques and variation of pitch on quantitative CT measures. These additional phantoms will include modifications of basic phantoms, such as the CATPHAN, and of the COPD Gene Lung Phantom by the addition of uniform tissue equivalent external rings. These rings will be of circular outer diameters of 30 and 40 cm and elliptical outer diameter of 25-30 cm and 35-45 cm. We will investigate the realizable dose reduction for the most common dose reduction methods and their impact on quantitative measures to determine the feasibility for their incorporation into longitudinal CT protocols. We will also investigate the effects of positioning, scan FOV, reconstruction algorithms, and pitch on quantitative CT measures, and the effects of dose reduction with and without the use of the AEC and IR. Scanning will be performed on the GE VCT and HD750 scanners both of which have software for the ASIR iterative reconstruction techniques, though the implementation of ASIR is different in these two scanners, thereby allowing for the possibility of comparing different iterative reconstruction algorithms. We do have access to all Lightspeed GE scanners at our institution from a 16 slice up to the HD750 and have extensive clinical and research experience with GE CT scanner technology as well as experience with longitudinal qCT measures in the lungs of asthma patients using the VIDA software package as part of the ongoing multicenter Severe Asthma Research Program. We could also work with other sites, such as the University of Iowa, which has access and extensive expertise with the Siemens scanner platform.

Primary goals and objectives

Specifically we propose to investigate the following:

1. The effects of pitch on image quality (image noise, resolution, and artifact) while changing rotation time and mA to maintain the same radiation dose, by maintaining a constant "effective mAs".
2. The effects of positioning scan FOV, image reconstruction algorithms (standard, detail, etc.) on qCT numbers for parenchyma and bronchial airway measures using VIDA.
3. The effects of automatic exposure control systems such as Smart mA on the GE systems that produce mA modulation in the Z and angular directions, on qCT numbers for parenchyma and bronchial airway measures using VIDA.
4. The effects of iterative reconstruction algorithms, such as ASIR on the GE systems, on qCT numbers for parenchyma and bronchial airway measures using the VIDA software.
5. The effects of dose reduction, with and without AEC and IR on qCT numbers for parenchyma and bronchial airway measures using VIDA. This will be done using phantoms and by the accurate addition of noise to raw projection data from clinical scans to simulate lower dose.

Deliverables

1. Comprehensive numerical information on the effects of pitch on image quality (image noise, resolution, and artifact), while adjusting rotation time and mA to maintain the same radiation dose, or constant "effective mAs".
2. Comprehensive numerical information on the effects of positioning, scan FOV, image reconstruction algorithms (standard, detail, etc.) on qCT numbers for parenchyma and bronchial airway measures using VIDA.
3. Comprehensive numerical information on the effects of automatic exposure control (AEC) systems, such as Smart mA for GE systems, on qCT numbers for parenchyma and bronchial airway measures using VIDA. Such exposure control systems produce mA modulation in the Z and angular directions that may impact local signal to noise.
4. Comprehensive numerical information on the effects of iterative reconstruction (IR) algorithms, such as ASIR on the GE systems, on qCT numbers for parenchyma and bronchial airway measures using the VIDA software.
5. Comprehensive numerical information on the effects of dose reduction, with and without AEC and IR on qCT numbers for parenchyma and bronchial airway measures using VIDA. This will be done using phantoms and by the accurate addition of noise to raw projection data from clinical scans to simulate lower dose.

Timeline [must include intermediate measurable milestones.]

0 - 3 months: Initial scans with COPD Gene Lung phantom and CATPHAN. Begin fabrication of other phantoms. Begin investigation into the addition of noise to raw projection data from CT phantom scans to simulate lower dose. Milestone: Initial results for deliverables 1 and 2.

4 - 6 months: Finish fabrication of phantoms and perform scans with complete set of phantoms involving deliverables 1-3. Milestone: Continue investigation into the addition of noise to raw projection data from CT phantom scans to simulate lower dose. Provide main body of results for deliverables 1 and 2, and initial results for deliverable 3 and 4.

7 - 9 months: Extend investigation into the addition of noise to raw projection data from CT phantom scans to simulate lower dose to clinical scans. Milestone: Completion of deliverables 1 and 2. Near completion of deliverables 3 and 5.

10 - 12 months: Complete study. Millstone: Completion of all deliverables 1 thru 5.