Background and Progress Progress

The CT Lung Density Biomarker Committee is working to harmonize and define quantitative CT (QCT) protocol requirements to obtain repeatable, robust metrics [1,2]. The relative area below 495 HU (90-865 HU) and the HU threshold at which the lower 15 percent of a lung histogram falls (Per15) through a published phantom (Figure 1) and convoluted dose escalation, has shown vendor inconsistencies using these QCT measures [3]. Therefore, more advanced image quality specifications are favored over preset parameter settings to allow flexibility in developing and supporting quantitative density measures [4].

Figure 1: Demonstrates the scanner variation across vendors in the COPDGene/study. Studies like COPDGene rely heavily on density scale (HU) accuracy to correctly phenotype the lung.

QCT Image quality specifications include:
1. Acquire a 3D volume encompassing the lungs in a single breath-hold of less than 15 seconds.
2. Acquire isotropic voxel size of 0.9 mm; an axial noise standard deviation of ≤ 200 HU for a matched kernel reconstruction (estimated lung equivalent foams by subtracting repeated helical scans).
3. Spatial resolution and noise thresholds were identified using the COPDGene/2 test object scanned with conventional dose (~7.5 mGy CT dose) protocol and using the same exposure function and IST 50*50 pixel Bucky images at equivalent density measures [5].

This approach enables vendors to adapt their architectures and reconstruction algorithms to meet desired measurement standards thus fostering creativity, better vendor involvement and compliance, and flexibility as CT systems continue to evolve.

To achieve higher precision of CT lung density as a biomarker that currently available, it is essential to harmonize scanner calibrations using the same phantom object to arrive at a consistent CT HU value for lung density assessments. The Committee coordinated scanning of the COPDGene phantom by vendors to assess scanner variations, which facilitated the following scheme for recalibration: The HU value for each voxel (averaged across the 4 mGy CT dose) volume, obtained using common software is plotted against the known physical density and corrected by a linear regression. The slope (a) and intercept (b) of the fit are used to describe the calibration function, which is then vendor dependent but material independent. The intercept (b) captures the air value that can deviate from -1000. The goal is to remove this scanner dependence by imposing a common slope and intercept, and the recalibration transforms each scanner’s HU value to HU:Value = a*HU + b

Baseline Performance Standard for AEC

To establish a ‘target’ or baseline performance standard for automatic exposure control (AEC), an anthropomorphic phantom with a low density foam (Figure 2/Top) was scanned using a current commercial dose CT protocol used in a multi-center clinical research study of severe asthma (SARP/2). In this approach, constant tube currents are adjusted up or down to one of three settings based on patient body mass index (BMI). AEC is based on the current tube current CTDL, estimated from the mean BMI = 2.6 mGy, medium BMI = 7.6 mGy, large BMI = 11.4 mGy).

AEC performance was estimated by subtracting repeated helical scans to obtain two noise realizations with the measurement derived from the standard deviation (SD) within a spherical volume of interest (VOI) of radius 13.5 mm scanned using phantoms of various equivalent body sizes under varying AEC parameter settings (Figure 3 and Table 1).