Agenda : Lung Density Breakout Session

1. Vendor COPDGene Phantom Study : Mathew Fuld and Bernice Hoppel
3. Dose reduction effects on emphysema metrics : Philip Judy

Vendor COPDGene Phantom Study

• Phantom Scanning
  – Same COPDGene Phantom – Round Robin Study
  – Univ of Iowa provided the tool for analysis
    • MTF
    • HU (mean + std dev across all inserts, water and air)
  – Three Dose Levels ( 5mGy, 3 mGy, 1.5 mGy)
  – 8-10 sec acquisition time for 40 cm z-coverage
  – Several kVps (80 - 140)
  – Multiple scans for variability

• Measurements
  • Noise Levels
  • Resolution Measurements
  • HU Variability
Vendor COPDGene Phantom Study

Goal is to generalize the profile to establish target specifications that meet the claims:

- Define the spatial resolution of the acquisition to be ~1 mm isotropic voxel within a 10 s breath-hold time.
- No IR and no AEC
- Equivalent smooth kernels (measure MTF using the edge response function)
1. Define the dose specification as 3 mGy CTDIvol (+/- 1.5 mGy based on patient size*) *means to
determine patient size suggested to be chest
dimension and BMI but not determined
definitively.
2. Target bias and standard deviation to be
determined from lowest density foams only
4 lb. (~ -950 HU) and 12 lb. (~ -700 HU) foams +
"lung" foam (~ -850 HU). “Lung” foam forms
the matrix of the phantom.
3. Edge response function used to match MTF’s
across vendor reconstructions.

Initial Findings from first round of Vendor scans using
the COPD Gene Phantom:
1. Differences of biases in the mean HU in 4 lb. and 12
lb. foams are as high as 9 HU for initial tests, but
waiting for other vendors before we make a final claim
on bias. Possible scanner calibration issues are being
followed up.
2. Standard deviations are closer but differ by ~5 HU
at the same foam densities.
3. This is the first round of scanning. A second round
will focus on harmonizing protocols to meet an agreed
upon specification.
Vendor COPDGene Phantom Study

Action items from vendor discussions
1. Complete analysis of first round of phantom scans. Particular focus on MTF, and mean +/- SD in the low density foams
2. On second round of scans desire to also scan NIST calbrated foams (known density and expected HU) in tandem with COPD Gene phantom
3. Recalibration of a specific scanner to establish if bias is the same as its initial estimate.

Automatic Exposure Control (AEC) Evaluation

• Goal: To evaluate dose reduction and the effects of automatic exposure acquisitions. Issue has been that vendors use various AEC methods and clinicians and radiologists assume AEC will further confound the quantitative differences between CT models.
• Task: Identify the appropriate phantom and compare AEC methods.
• Status: Phantom has be identified and scans are being performed
Solid Torso Phantom and Experiment

- Alderson Phantoms, now RSD- Radiology Support Devices, Model RS-111T.
- Scans with a NI=40, 50, 64, 80 with SmartmA and AutomA to measure the effect of global NI to noise measured in the lung

Volume Histograms

NI=40

Mean
HU_{segmented\_lung\_AEC} = -600.34 ± 18.36
Volume Histograms

NI=80

Mean

$\text{HU}_{\text{segmented lung AEC}}$ = -599.44 ± 37.07

Noise Measurements

- Two identical scans were performed at each noise index, and measurement of the noise was determined via digital subtraction of the images of each series.
- Volumes of interest consisting of spheres of radius 13.5 mm were placed at the locations shown in the figure on the left.
- The standard deviation of the HU in the voxels of the sphere, $\sigma_{\text{HU}}$, was used as the metric of noise.
Dose reduction effects on emphysema metrics

**Recommendation to COPDGene Investigators if they want lower dose in Round 3 exams: Lower inspiration acquisition mAs to 50 from 200.**

- Can use existing expiration studies to estimate effects using 50 mAs acquisitions and validate procedures to obtain 200 mAs acquisition emphysema results.
- QIBA working profile recommends a nominal 50 mAs acquisition.
- ECLIPSE successfully used a 40 mAs acquisition.
- Acquisition specifications will be same for inspiration and expiration exams.

Dose reduction effects on emphysema metrics

- COPDGene is considering adding a 50 mAs inspiration exam to remaining second round exams
- Opportunity to compare quantitative results from 50 mAs exams to 200 mAs.
- I presented a theoretical prediction of the effect (bias) based on existing 50 mAs expiration exam.
- Proposed study would:
  - Evaluate my bias prediction
  - Estimate repeatability emphysema metric
  - Determine difficulty of measuring airway morphology using 50 mAs exams
Volume correction using duplicate COPDGene exams

Meta analysis for precision claim of profile concluded that lung volume correction will improve repeatability of lung density measurements. However, no agreement which method should be used. This investigation will use about 30 duplicate exams from COPDGene Study to compare various methods.

Example: lung volume and lung density metric “Perc15”

• Rationale:
  – Natural progression: after age 50, lung density declines about 1.5 g/L per year => 1.5 HU per year.
  – Current repeatability coefficient (within-subject variance) is 10 times higher.
  – Perc15 value changes depending on state of inflation.
  – General consensus for the need of volume correction, but lack standard method of performing volume correction.