The effect of inspiration on airway dimensions measured in CT images from the Danish Lung Cancer Screening Trial

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Assessing pulmonary perfusion in emphysema: automated quantification of perfused blood volume in dual-energy CTPA
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Purpose: To determine whether automated quantification of lung perfused blood volume (PBV) in dual-energy computed tomography pulmonary angiography (DE-CTPA) can be used to assess the severity and regional distribution of pulmonary hypoperfusion in emphysema.

Methods and Materials: We retrospectively analysed 40 consecutive patients (mean age 67 ± 13 years) with pulmonary emphysema, no cardiopulmonary comorbidities and a DE-CTPA negative for pulmonary embolism. Automated quantification of global and regional pulmonary PBV was performed using the syngo dual-energy application (Siemens Healthcare). We further quantified the global and regional percentage of voxels with a CT density < -900 HU. Emphysema severity was rated visually and pulmonary function tests were obtained by chart review.

Results: Global pulmonary PBV showed a moderate but highly significant negative correlation with residual volume (RV) in % of predicted RV (r=0.62, p=0.002, n=23) and a positive correlation with forced expiratory volume in 1 second (FEV1) in % of predicted FEV1 (r=0.67, p<0.001, n=23). Global PBV values strongly correlated with diffusing lung capacity for carbon monoxide (DLCO, r=0.80, p < 0.001, n=15). Pulmonary PBV values decreased with visual emphysema severity (r=0.46, p=0.003, n=40). Moderate negative correlations were found between global PBV values and parenchymal hypodensity in a per-patient (r=0.63, p < 0.001, n=40) and per-region analyses (r=0.62, p < 0.001, n=40).

Conclusion: DE-CTPA allows simultaneous assessment of lung morphology, parenchymal density and pulmonary PBV. In patients with pulmonary emphysema, automated quantification of pulmonary PBV in DE-CTPA can be used for a quick, reader-independent estimation of global and regional pulmonary perfusion, which correlates with pulmonary function tests.

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B-0162 14:18
Densitometry on MDCT in cystic fibrosis: radiological evidence for emphysema
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Purpose: The present study was conducted to employ computational densitometry based on multi-detector computed tomography (MDCT) of the chest to characterise and quantify emphysema in cystic fibrosis (CF), identical to its routine clinical application in chronic obstructive pulmonary disease (COPD). Results were validated against pulmonary function testing (PFT, i.e. forced expiratory volume in 1 second or FEV1% predicted), residual volume (RV) and total lung capacity (TLC). Patients without lung disease (NORMAL) served as controls.

Methods and Materials: MDCT from n=41 CF (median FEV1=41%, median age 20a) and n=20 NORMAL (FEV1=102, 30a) were subjected to densitometry. Lung volume (LV) and emphysema volume (EV) were segmented (threshold -950 Hounsfeld units), and the emphysema index was computed (EI). All results were correlated with parallelled PFT (median gap 0d, range 0-73d).

Results: Mean LV was 4681 ml in CF and 3967 ml in NORMAL (n.s.). Significant EV was found in CF (mean 457 ml) compared to NORMAL (78 ml) (p<0.05). Median EI was elevated to 7% in CF patients, but 1% in NORMAL. EI correlated well with FEV1% in CF (r=0.55) and NORMAL (r=0.67), but with RV (r=0.69), and RL/TLC (r=0.47) in CF only (p<0.05). Importantly, EI increased markedly with age in CF (r=0.67, p<0.001), starting at 13a.

Conclusion: Our results indicate the development of progressive emphysema in chronic CF, which should be considered for new therapeutic approaches. Densitometry may introduce new quantitative and prognostic parameters into severity assessment of CF lung disease.

B-0163 14:27
The effect of inspiration on airway dimensions measured in CT images from the Danish Lung Cancer Screening Trial
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Purpose: Airway dimensions measured from CT are increasingly being used to evaluate the relative change in lumen diameter (LD) and wall thickness (WT) in airways of generation 0 (trachea) to 6 based on relative changes in the segmented total lung volume (TLV).

Results: On average, 1.0, 2.0, 3.9, 7.6, 15.0, 25.0 and 27.3 airs were included per subject from generations 0, 1, 2, 3, 4, 5 and 6, respectively. Relative changes in LD were positively related to changes in TLV and coefficients increased with generation: 0.20 (+0.02), 0.19 (+0.02), 0.21 (+0.01), 0.25 (+0.01), 0.29 (+0.01), 0.34 (+0.01), 0.37 (+0.01). Relative changes in WT were inversely related to changes in TLV and generation: -0.01 (+0.02), 0.01 (+0.01), -0.02 (+0.01), -0.03 (+0.01), -0.05 (+0.01), -0.09 (+0.00), -0.08 (+0.00).

Conclusion: Subjects who inspire deeper prior to scanning tend to have larger LD and smaller WT. This effect is more pronounced in higher generation airways. Thus, adjustment for inspiration level is needed to accurately assess airway dimensions.

Author Disclosures: M. de Bruijne; Grant Recipient; AstraZeneca.

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Chronic bronchitis in large airway: airway wall measurements on thin-slice low-dose CT
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Purpose: Chronic bronchitis (CB) is caused by smoking and characterised by chronic inflammation and remodelling of the airway wall, commonly in large airways. The study purpose is to determine differences in airway wall thickness (AWT) and wall area percentage (WAP%) between subjects with and without CB symptoms.

Methods and Materials: 50 heavy smokers with CB symptoms (cough, mucus, dyspnoea and wheezing) and 50 heavy smokers without CB symptoms were randomly selected from 1,413 participants in a lung cancer screening trial. Airway walls were measured on images in thin-slice low-dose CT with a dedicated software tool, for airways with a luminal diameter ≥5 mm in 5 selected bronchi (RB1, RB4, RB10, LB1+2 and LB10). Differences in measurements between the groups were assessed by t-test. The association between CB symptoms and AWT and WAP% was analysed using multiple linear regression adjusted for age, body mass index, smoking habit, amount of emphysema, and lung function.

Results: Mean AWT measured at 5 bronchi was 1.5±0.44 mm and 1.4±0.40 mm in subjects with and without CB symptoms, respectively (P<0.001). WAP% was 47±12% and 43±11%, respectively (P<0.001). WA% was related with diffusing lung capacity for carbon monoxide (DLCO, r=0.80, p<0.001, n=15). Pulmonary PBV values decreased with visual emphysema severity (r=0.46, p=0.003, n=40). Moderate negative correlations were found between global PBV values and parenchymal hypodensity in a per-patient (r=0.63, p<0.001, n=40) and per-region analyses (r=0.62, p<0.001, n=40).

Conclusion: Subjects who inspire deeper prior to scanning tend to have larger LD and smaller WT. This effect is more pronounced in higher generation airways. Thus, adjustment for inspiration level is needed to accurately assess airway dimensions.

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