

88. Standard of care, incidental findings, image acquisition

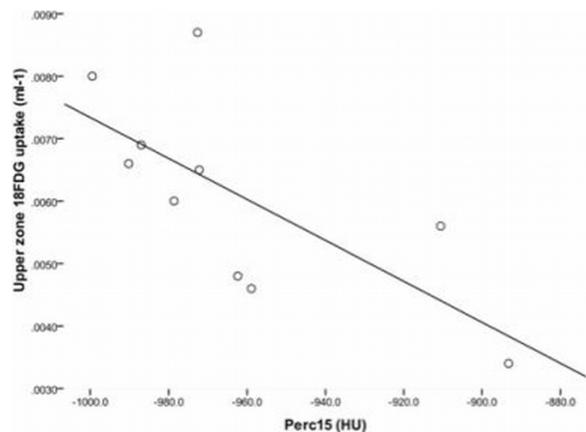
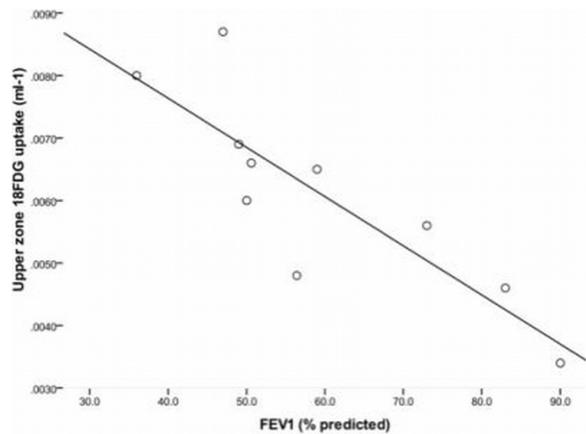
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Quantitative ¹⁸F-FDG PET-CT for the assessment of pulmonary neutrophilic inflammation in COPD

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Introduction: Neutrophilic inflammation is of pathogenetic importance in COPD but non-invasive clinical assessment is problematic. We assessed the utility of ¹⁸F-FDG PET-CT as a spatially-informative surrogate measure of pulmonary neutrophilic inflammation in COPD.

Methods: ¹⁸F-FDG PET-CT imaging, CT densitometry, clinical and physiological assessment were performed in 10 patients with usual COPD. Regional pulmonary ¹⁸F-FDG uptake was estimated by 3-D Patlak graphical analysis as an indicator of pulmonary neutrophilic glycolytic activity and related to lung physiology and lung density.



Results: ^{18}F FDG uptake in the upper lung was greater than in the middle and lower lung regions and correlated with physiological and CT densitometric measures of disease severity (FEV1% predicted, $r = -0.848$, $p = 0.001$; FEV1/FVC, $r = -0.918$, $p < 0.001$; Kco% predicted, $r = -0.624$, $p = 0.027$; 15th percentile point, $r = -0.709$, $p = 0.011$).

Conclusions: The ^{18}F FDG signal seen in patients with COPD likely relates to the presence of centrilobular emphysema. The method has a potential role as an imaging biomarker in mechanistic and interventional studies in patients with usual COPD.

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Optical coherence tomography measurements of subpleural alveolar size compared to micro-CT and ray-trace modeling

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Optical frequency domain imaging (OFDI) is a promising second-generation optical coherence tomography (OCT) modality for visualization of alveolar structure and function in vivo due to its microscopic resolution ($\sim 10\mu\text{m}$) and fast imaging speed ($> 100\text{fps}$). In order to enable quantitative conclusions about alveolar behavior under various ventilation strategies or pathologies, it was crucial to investigate the validity of alveolar size measurements obtained from OFDI images.

Therefore, we compared the cross-sectional area, perimeter, volume, and surface area of matched subpleural alveoli from micro-CT ($2.9\mu\text{m}$ resolution) and OFDI images of fixed air-filled swine samples. Furthermore, we developed a ray-tracing model that approximates the reconstructed alveolar size within OFDI images based on potential refraction effects that are not visible in micro-CT images.

We discovered that the relative change in size between alveoli was extremely well correlated between the two imaging techniques ($r > 0.9$, $p < 0.0001$), but OFDI images underestimated absolute sizes compared to micro-CT images by 27% (area), 7% (perimeter), 46% (volume), and 25% (surface area) on average. Using our model and OFDI measurements of the refractive index for fixed and fresh lung tissue, the experimentally obtained OFDI measurements could be re-scaled to approximate the micro-CT measurements with dramatically reduced error ($< 10\%$ for all size parameters).

In this study, we have successfully validated relative alveolar sizes as measured within OFDI images and show the potential to obtain absolute size measurements with the use of predictive correction factors.

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Efficacy of chest CT in establishing the cause of primary spontaneous pneumothorax

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Background: The cause of primary spontaneous pneumothorax (PSP) is thought to be a rupture of a subpleural bleb or bulla (BB). Thoracoscopy is considered the gold standard in determining the presence of BB, but this is an invasive procedure that has limitations. Recent studies have shown CT to be almost as sensitive for these findings, but, these studies were either not designed specifically to test this theory, or had a small number of subjects.

Objective: To evaluate the potential of chest CT for preoperative diagnosing of pathologies in PSP patients.

Methods: The study included 42 patients with PSP who underwent preoperative non-contrast chest CT followed by wedge pulmonary resection and pleurodesis through mini-thoracotomy. Results of CT, surgery and pathological study of resected tissue were compared.

Results: The sensitivity and specificity of CT was 96.4% and 76.5% respectively. Correlation was also found comparing the size of BB measured on CT and the pathological study. In 14 cases (30%) no BB were found on CT, during surgery or pathological examination. In all of these cases a finding known as "apical lines" (AL) was demonstrated on CT. The pathological examination of the resected lung specimens showed fibrosis and emphysema.

Conclusions: We found CT to be a very sensitive method of diagnosing BB in PSP patients. The study also demonstrated the presence of AL in PSP patients which were the radiological manifestation of limited fibrotic and emphysematous changes in the apex which may be the cause of PSP in our series of patients. Preoperative diagnosis of the cause of PSP helped to employ the proper surgical technique and to prevent recurrence of PSP.

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Assessing the standard and accuracy of chest x-ray reporting by medical physicians in an acute medical take

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Introduction: The reporting of CXRs for medical patients admitted to hospital vary across Europe. Comparison between physicians and radiology reporting has suggested radiologists provide improved quality (1) and accuracy (2) of reporting. In our trust the radiologist report on all the admission CXRs but this may not be available at the time of physician review.

Aim: To assess if disagreement in reporting between general physicians and a radiologist would have an impact on the medical management of a patient.

Method: We retrospectively compared the reporting of 50 CXRs by the medical physician with that of a radiologist.

Results: The overall concordance of reporting was 78%. There were 21/50 normal CXRs of which the physician correctly reported 20/21 (95%) as normal. The remaining were either acutely abnormal (14/50, 28%) or had chronic abnormal changes (15/50, 30%). Only 6/14 (43%) acutely abnormal CXRs were reported correctly and 11/15 (73%) reported on chronic changes by the physician.

Conclusion: Correctly identifying an acute diagnosis was less than 50%, particularly differentiating between pneumonia and heart failure, yet many trusts require the physician to report on CXRs. Undergraduate and post-graduate training in internal medicine does not formally train or examine in radiology and given these findings more training and service development needs addressing for patient safety.

References:

- [1] Weiner SN. Radiology by nonradiologists: is report documentation adequate? *Am J Manag Care.* 2005 Dec; 11(12).
- [2] Zohair AI Aseri. Accuracy of chest radiograph interpretation by emergency physicians. *Emergency Radiology.* 2009; 16(2).

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X-ray interpretation: A self-assessment survey

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Aim: To assess the confidence of hospital based doctors in reviewing plain radiographs.

Methods: An online e-survey tool collected responses from 600 doctors from the West Midlands area, UK. They were asked to rate their confidence as: not confident, will always need senior help; somewhat confident; confident in interpreting some conditions; confident of routine and common conditions; very confident, seek radiology advice occasionally; highly confident, almost never seek radiology advice. We also asked them to self assess their confidence in identifying some common findings on x-rays; and collected data on any formal or informal training they had received.

Results: 241 (40%) responses were received; of these 165 were from medical and 76 from non-medical specialities. The level of confidence expressed by medical doctors in interpreting chest x-rays (48.5%) was significantly higher than abdominal (17.4%) and skeletal x-rays (6.2%). Doctors in non-medical specialities were better with skeletal x-rays (22.5%).

Of the 241, 70 had been to a radiology course, 127 had some form of formal and 57 had only informal training. 11 (9 medical trainees) did not have any form of training. 177/241 felt that there should be radiology training for all doctors, and it should be a compulsory part of the training portfolio.

Conclusion: There was variability in confidence amongst hospital doctors in interpreting x-rays across training grades and clinician groups. Basic radiology training as a separate competency may need to be considered in the training programmes and e-portfolio of hospital doctors. Training in chest radiograph interpretation should merit focused attention in the respiratory specialty training as well as the HERMES curricula.

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Lung ultrasound as an ambulatory investigation tool in respiratory medicine: An audit of clinical practice

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Introduction: Lung ultrasound is an imaging tool which is increasingly used by nonradiology physicians in the intensive care unit and the emergency department. However, there is a lack of data concerning lung ultrasound directly provided by the pulmonologist during ambulatory investigations.

Methods: The study is an audit of clinical practice of the respiratory diseases ambulatory of a tertiary care university hospital. Consecutive lung ultrasounds, performed by pulmonologists, were prospectively recorded from April 2011 to

February 2012. The main indication, methods and clinical consequences were registered on a web-database.

Results: 8 experienced operators performed 112 exams on 92 patients (aged 66±4 years, mean ± sd, 42 females). The mean duration of the exam was 8±2 minutes. B-mode was used in all patients, while functions such as M-mode and Color-Doppler were needed in 10% and 4%. Convex probe was the most used as a single transducer (82% of the cases); linear probe was used in association with the convex or as unique probe in 22% of the exams. The main indications were: pleural effusion (32%), thoracentesis (25%), lung consolidation (12%), pneumothorax (10%), dyspnoea (8%), acute exacerbation of COPD (6%), heart failure (4%), and diaphragm dysfunction (2%). The pulmonologist who executed the exam reported that in 72% of the cases lung ultrasound had a clinical impact, even if minor, on patient management.

Conclusions: The execution of lung ultrasound is a rapid and feasible imaging tool which may often provide clinically relevant data during ambulatory consultations. Further studies will be needed to evaluate the impact of lung ultrasound on outpatients management.

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One year's experience of mobile bedside chest ultrasound service for pleural diseases in a district general hospital

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Introduction/Objectives: The role of chest ultrasound for the management of pleural diseases has evolved rapidly over the last few years. The National Patient Safety Agency's rapid response report and the latest British Thoracic Society guidelines have recommended the use of chest ultrasound prior to intervention in pleural effusion. We describe our experience with using mobile bedside chest ultrasound including complication rates, impact on waiting time and length of hospital stay.

Method: Prospective data from all patients receiving mobile chest ultrasound over a 12 month period in 2011 was collected. Scans were performed by an acute medicine physician and respiratory registrars with level 1 competency in chest ultrasound as classified by the Royal College of Radiology. Case notes, coding and radiology data were assessed, and comparisons made to waiting time and length of hospital stay for those receiving chest ultrasound in the radiology department.

Results: Overall 126 scans were evaluated with 123 performed the same day as requested and 3 the next day. Of those, 24 were followed by chest drain insertion, 56 by pleural aspiration and 46 with no intervention. Two patients had small pneumothoraces post aspiration (3.8%) whilst 1 chest drain insertion and 2 pleural aspirations failed. Average hospital stay was 13.3 days compared to 18.6 days for those having scans in the radiology department.

An average time of 21 minutes which included scanning duration, collecting and returning the device was documented in 71 patients.

Conclusion: Mobile bedside chest ultrasound when performed by level 1 competent physicians appears to be safe and considerably reduces length of hospital stay.

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Incidental findings on CTPA at a district general hospital

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Background: CT Pulmonary Angiogram (CTPA) is the gold standard investigation for Pulmonary Embolism (PE) in the UK¹.

Aims: Due to the quality of CTPA imaging, incidental findings are often identified. We investigated the incidence of these findings on CTPA studies done at a large district general hospital.

Methods: CTPA requests over a 12 month period in 2011 were reviewed retrospectively. Data was collected regarding PE, incidental findings and chest x-ray (CXR) reports at time of CTPA.

Results: A total of 216 CTPA reports were analysed. Results are seen in Table 1. Of the patients who had consolidation on CTPA, 9 (17%) had no consolidation seen on CXR.

In those with a pleural effusion on CTPA, 42 (67%) had no effusion on CXR and of the patients who had a malignancy, 21 (75%) had not had this detected on CXR.

Table 1 CTPA Incidental Findings

Result	Number	%
Effusion	62	28.7
Consolidation	52	24.1
Emphysema	43	19.9
Malignancy	28	13
Pulmonary Embolism	24	11.1
Fibrosis	23	10.6
Lymph Nodes	21	9.7
Cardiomegaly	18	8.3
Atelectasis	17	7.9
Collapse	11	5.1
Bronchiectasis	10	4.6
Pneumothorax	2	0.9
Pulmonary oedema	2	0.9

Out of 216 patients, 15 (6.9%) had no CXR prior to CTPA and 13 (6%) had no formal CXR report.

Discussion: At our centre, CTPA yielded 11% diagnosis rate for PE. A sizeable number of incidental findings were detected resulting in further investigations and treatments of patients. The sensitivity of CXR is not sufficient to rule out consolidation in this set of patients. This study emphasises that CTPA is important in diagnosis of PE, but also in identifying alternative pathologies not seen on routine CXR

Reference:

[1] BTS Guidelines for the Management of Suspected Acute Pulmonary Embolism. *Thorax* 2003; 58: 470-484.

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Evaluation of incidental findings other than PE on CT pulmonary angiogram

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Background: PE is a common cause of admission to hospital, with CTPA increasingly being used to make this diagnosis. However, incidental findings other than PE are frequently noted. Our objective was to investigate the incidence of these, and the implications in patient management.

Method: This is a retrospective study which involved all inpatients who had undergone CTPA from June until November 2009. Data was obtained from PACS and electronic records. Abnormalities other than PE was identified and new lesions were differentiated from old.

Results: A total of 112 patients were identified with the majority being male 67 (60%). The mean age was 61 years (range 23 to 97). SOB was the most prevalent presenting symptom in 62 (55.3%) followed by chest pain 37 (33%). Chest radiographs were performed in 110 (98.2%) patients, of 52.7% were normal. PE was found in 28 (25%) patients. Incidental findings were seen in 56 (50%) patients, 40 (71.4%) of these were new of which 28 (70%) of them needed further interventions. The most prevalent findings were pneumonia 22 (39%) followed by fibrosis 7 (12.5%), effusions 5 (8.9%) and lung masses 4 (7%). 10 patients had both PE and incidental findings.

The average length of stay was 7.3 days. Patients with additional pathology stayed a day longer (7.8 days) than those without (6.8 days).

Conclusion: In patients with suspected PE, CTPA has become a routine investigation with a yield of 25% in our study. Incidental pathology was evident in 50% of scans, which is in keeping with other studies. The addition of these findings on CTPA impacts on the length of stay of patients in hospital by one day, and has important implications for the acute clinical management of these patients.

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Audit of the investigation of suspected pulmonary embolism in pregnancy

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Introduction: The diagnosis of pulmonary embolism (PE) in pregnancy relies upon criteria based clinical assessment supported by the use of appropriate imaging modalities. There is wide discrepancy between clinicians in the way the condition is investigated and this may have profound implications for diagnosis, resource allocation and radiation dose delivered to the mother and foetus.

Methods: Using the radiology database, all pregnant women who were investigated for PE using any of chest x-ray (CXR), bilateral leg duplex scans, perfusion scintigraphy (Q scan) or CT pulmonary angiography (CTPA) during a two year period from April 2009 till March 2011 were identified. The authors looked at the diagnostic algorithm adopted for each patient.

Results: 60 patients were identified. The sequence of imaging varied significantly, with patients falling into one of 7 main groups. 14 (23%) patients had CXR followed by CTPA; 11 (18%) had CXR followed by Q scan; 10 (17%) had CXR, leg duplex scans and CTPA; 9 (15%) had CXR, leg duplex scans and Q scan; 7 (12%) had CXR and leg duplex scans; 5 (8%) had CTPA alone and 3 (5%) had leg duplex scans followed by CTPA. There was a single case where a patient already diagnosed with deep vein thrombosis (DVT) on recent leg duplex scan was investigated for possible PE with CXR and CTPA.

Conclusions: The audit shows that there is a lack of standardised pathway for suspected PE in pregnancy and the choice of investigative modality was clinician dependent. There is a need for the international medical community to develop robust guidelines to allow standardised care, effective use of resources and minimize maternal and foetal radiation exposure.

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MDCT in tracheal stenosis assessment

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Purpose: MDCT assessment of the degree and extent of tracheal cicatricial stenosis (CST) in comparison to the results of endoscopic examination and intraoperative data.

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Materials and methods: The research included 36 patients with postintubation CST who underwent MDCT from the larynx to the carina levels. Stenosis degree determination based on measurements performed at the level of maximal tracheal stenosis, levels above and below it. By accepted classification of the stenosis degree Grade1 CST with narrowing of the lumen at 1/3 of the diameter in 2 cases, Grade 2 (1/3 to 2/3 of the diameter) in 17, Grade 3 (more than 2/3) in 17. The distance from the proximal to distal intact tracheal wall was defined as the length of the stenosis. According to the accepted classification limited stenosis (up to 2 cm) was detected in 10 cases, extended (more than 2 cm) in 26 cases.

Results: A comparative analysis showed significant coincidence in MDCT (considering the average values and deviations for groups MDCT $3,17 \pm 1,37$) and intraoperative data ($3,48 \pm 1,33$), and difference in MDCT ($3,17 \pm 1,37$) and fiberoptic data ($2,81 \pm 1,28$). As a result, in the degree of the stenosis extent assessment the correlation coefficient between MSCT and intraoperative studies was $r=0,3$ with $p=0,32$; between MSCT and fibrobronchoscopy was $r=0,36$ with $p=0,25$. In the stenosis degree assessment the correlation coefficient between MSCT and fiberoptic was $r=1,22$, with $p=0,06$ ($p=ns$); between MSCT and intraoperative data was $r=1,58$, with $p=0,02$ ($p<0,05$). The method gave sensitivity of 100%.

Conclusions: MDCT with 3D-reconstruction images provides indispensable information on the degree and extent of tracheal stenosis and has higher diagnostic value compared with endoscopic examination.

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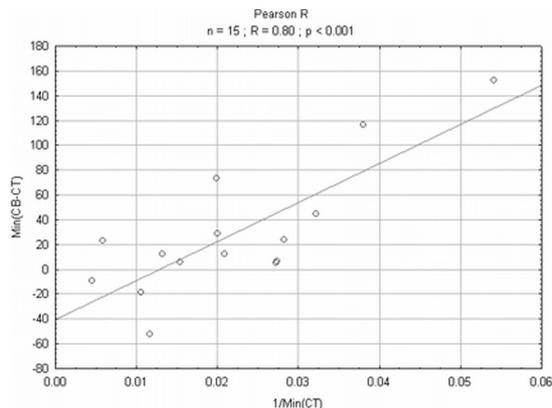
The difference in upper airway morphology between supine and upright posture

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Introduction: The effect of upper airway (UA) morphology and especially the effect of the minimal cross sectional area (CSA) on lung deposition of inhaled medication (IM) is significant. However since IM is used when a patient is upright, conventional computed tomography (CT) data may not provide accurate information on the influence of the UA on lung deposition. The objective of this study is to evaluate variability in UA morphology for supine posture using CT vs. upright posture using cone beam CT (CBCT).

Materials and methods: A total of 20 normal subjects were included. 15 valid CBCT scans could be included as the rotating gantry of the CBCT touched the shoulders of the broad-shouldered subjects, causing motion artifacts. The UA CT scans were performed using the GE VCT LightSpeed scanner and the CBCT scans were performed using the ISI i-CAT scanner.

Results: It is found that the CT scans were characterized by lower CSAs as compared to CBCT (Minimal CSA, $p = 0.036$, Average CSA, $p = 0.006$). The minimal CSA in the CT scan could accurately predict the difference in minimal CSA between CT and CBCT as indicated in the figure.



Conclusions: It can be concluded that the UA morphology is different between upright and supine position. From the supine CT image, it can be predicted how large the minimal CSA will be when the subject is in an upright position. This function can be used to generate a correction factor for assessing lung deposition of IM.

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The relationship between NT proBNP and CT lung density in long term smokers

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Introduction: Cardiovascular conditions are reported to be the most frequent cause of death in COPD.

Aims and objectives: The relationship between N-terminal prohormone of brain natriuretic peptide (NT proBNP) as a surrogate marker of congestive heart failure (CHF) and CT lung density remains unclear. Pulmonary oedema leads to increased CT lung density. Little is known about milder CHF and CT lung density. Lung cancer screening provides an opportunity to study this relationship.

Methods: 500 long-term smokers were selected from the Danish Lung Cancer Screening Trial (DLCST). Smoking habits were recorded and spirometry was performed. CT lung density was measured automatically by in-house developed computer software and expressed as the volume adjusted 15th percentile density (PD15). NT proBNP was measured as part of a panel of biomarkers. The 194 persons, who had the CT scan and the blood sample performed the exact same day, were included in a multiple regression model. The model included gender, pack years, number of cigarettes a day during the last month, COPD severity, and NT proBNP with PD15 as outcome variable.

Results: Female sex ($+20.5 \text{ g/l}$, SE 1.9, $p < 0.001$), high number of cigarettes a day ($+0.6 \text{ g/l}$, SE 1.1, $p < 0.001$) and no or mild COPD ($+0.2$, SE 0.1, $p < 0.001$) were associated with a higher PD15, but there was no correlation with NT proBNP ($+0.0001$, SE 0.002, $p=0.959$).

Conclusions: PD15 was not correlated to NT proBNP. Therefore milder degrees of CHF seem to have little influence on CT lung density. Lung density is higher in females, in people without COPD and in heavy current smokers.

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Pulmonary emphysema: Qualitative assessment at CT of presence and subtypes

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Pulmonary emphysema is defined by morphology and is a heterogeneous disease with variably defined subtypes. We hypothesized that reliable detection of the presence of emphysema and its subtypes by visual CT assessment could be achieved by application and training on standard definitions of subtypes and severity.

CT scans from 40 participants were selected randomly from a population-based cohort of participants ages 60-80 years with ≥ 10 pack-year smoking history. Non-contrast CT scans (120 kVp, 100 mAs, 0.75 mm) were performed at full inspiration and sharp filter reconstruction. Standard definitions of centrilobular (CLE), paraseptal (PSE) and panlobular (PLE) emphysema subtypes and severity were developed and three readers (2 chest radiologists, 1 pulmonologist) trained. The three readers independently assessed the 40 scans plus 10 replicates. Intra- and inter-reader agreement were assessed using unweighted Cohen's κ and intraclass correlation coefficient (ICC), respectively.

Results: The 40 participants had a mean age 68 ± 5 years, 40% were current smokers, and 55% had chronic obstructive pulmonary disease. The κ statistic was 0.91 for intra-reader agreement on presence of any emphysema and 0.74 for inter-reader agreement. ICC for intra- and inter-reader emphysema severity was 0.96. Intra-reader agreement for presence of emphysema was moderate to almost perfect depending on subtype (κ : 0.57-0.84); inter-reader agreement was good for CLE (κ : 0.67), moderate for PSE (κ : 0.32) and absent for PLE (κ : 0.06).

Conclusions: This protocol for the visual assessment of chest CT can reliably detect the presence and extent of emphysema, in addition to selected emphysema subtypes.

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MDCT and MRI DWI early signs of COPD

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Cigarette smoking is the leading cause of COPD. Most people who have COPD smoke or used to smoke some form of tobacco. But nonsmokers can develop COPD also.

Purpose: The main aim is to find early MDCT or MRI signs of COPD in young population of smokers, before developing the first clinical symptoms.

Material and methods: We examined 5863 patients from 18 to 35 years old. 3101 were male, 2762 female. All patients were examined on 16 or 64 MDCT using all advanced methods like virtual bronchoscopy, emphysema software we created, histogram, huge variation of filters and MDCT pulmonary angiography and MDCT perfusion. Patients with signs of COPD were examined by 1.5T MRI with DWI.

Results: Patients were examined by MDCT because of different reasons, some of them because of acute respiratory symptoms, mostly influenza but also group of patients voluntarily screened for lung cancer. We find signs of early COPD in 603 (10.28%) patients. All patients with signs of any other chronic disease or lung cancer were not matter of this study. Also we did not use patients with history of hemoptysis, even small one. In patients were we find signs suspect for COPD we performed MDCT pulmonary angiography to find any signs of vascular abnormality which could mislead us. MRI with DWI was performed to determine small vessels. In all patients we find areas of lower density than lung parenchyma. All areas were in peripheral parts of the lung, on left side of the lung in 61%. We

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also had control examination after two years in 6 patients, in all patient areas of emphysema were bigger.

Conclusion: Signs of COPD can be found earlier than first symptoms are visible. MDCT with variety of tools and MRI with DWI are very useful for early diagnosis.

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A functional and radiological multiparametric approach to the study of parenchymal features of chronic obstructive pulmonary disease

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Chronic obstructive pulmonary disease (COPD) includes a range of changes ranging from chronic bronchitis to emphysema.

We evaluated if integration of lung function tests and computed tomography (CT) scan allows a better characterization of patient with COPD.

23 patients (5 females) underwent lung function test and six-minute walk test (6mWT).

We used a third-generation, continuous-rotation helical 64-rows CT scanner with volume acquisition to measure extent of emphysema (per cent and absolute value) at full inspiration and at the end of forced expiration.

The extent of emphysema corresponding to lung volume with attenuation between -950 and -1024 HU at TLC [Emphysema Index TLC (EITLC)] and RV [Emphysema Index RV (EIRV)] was evaluated.

EITLC was 1.21 ± 0.96 L whereas EIRV was equal to 0.76 ± 0.57 L and CT measurements of lung volumes were directly related to static lung volumes.

Both EITLC and EIRV were related to the ratios FEV₁/FVC, FEV₁ (% of predicted), TGV, RV and TLC.

Emphysema extent was explained by multiple regression model:

$EIRV = -2.12 + 0.02 \times \Delta AaO_2 + 0.29 \times TGV + 0.05 \times \text{Expiratory time} + 0.28 \times \text{Sex}$ ($r^2 = 0.75$, $p = 0.0001$)

$EITLC = -3.00 + 0.04 \times \Delta AaO_2 + 0.38 \times TLC + 0.31 \times \text{Sex}$ ($r^2 = 0.49$, $p = 0.0064$).

Patients with both EITLC and EIRV > median value of each index showed the emphysema extent related to FEV₁/FVC, FEF_{25-75%} and mean SpO₂ during 6mWT. Emphysema, assessed by CT scan, could be explained by lung function measurements reflecting lung hyperinflation and the impairment of pulmonary gas exchange. Emphysema extent, independent of lung volume, is related to indices of expiratory flow limitation.

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Regional differences in specific gas volume in the healthy lung

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Specific gas volume (SVg) converts CT lung density into the physiological meaningful index of volume of gas per gram of tissue (Salito, C. et al. Radiology 2009; 253:380-389). The aim of this study was to establish a baseline of SVg values for healthy lungs, to study regional differences of SVg in the different lung segments and to evaluate the influence of the reconstruction kernel on SVg parameters.

CT scans of 10 healthy volunteers were performed during breath holding at total lung capacity (TLC) and residual volume (RV). CT images were reconstructed using Siemens b30f and b50f convolution kernels. For each broncho-pulmonary segment, one cylindrical region of interest within the parenchyma was selected.

Mean SVg was significantly higher with b50f both at TLC and RV (12.1 vs 7.5 ml/g, $p < 0.001$) while median SVg was not affected by the reconstruction filter (7.8 vs ~2.9 ml/g for TLC and RV, respectively). $\Delta SVg = SVg_{TLC} - SVg_{RV}$ was independent of broncho-pulmonary segment.

Variability of $\Delta SVg/\Delta V$ values between different broncho-pulmonary segments within the same subject and between different subjects within the same broncho-pulmonary segment was very low. Higher values of SVg were found in more anterior locations with little to no cranio-caudal or lateral dependence.

In conclusion, in healthy subjects SVg and ΔSVg are highly homogeneous within the lung. Conversely, in emphysema the expected larger heterogeneity can potentially be used as a measure of inhomogeneous lung emptying and a biomarker for surgical planning and post-treatment evaluation.

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Comparison of aerosol deposition pattern in healthy subjects: 3D SPECT measurements vs simulation results

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Introduction: A clinical study designed to validate computational models of aerosol deposition using controlled parametric experiments has been completed and the experimental conditions have been simulated using analytical models of aerosol deposition.

Objectives: For the modeling side of this study, the aim was twofold: (i) to introduce realistic asymmetric features in the description of the human respiratory tract and (ii) to compare the simulated aerosol deposition patterns within the lungs with measurements.

Methods: The 6 healthy subjects performed 2 inhalations each, which differed by a single controlled parameter: particle size, ventilation regime, or carrier gas. 3D Single Photon Emission Computed Tomography (SPECT) was performed to measure aerosol deposition location in the respiratory tract.

An analytical model was used to mimic aerosol inhalation experiments and simulate particle deposition within the lungs. Simulations were performed using asymmetric lung morphologies based on patient's morphometric data extracted from High Resolution Computed Tomography images, such as length and diameter of the first airway generations, and lobar volumes (in terms of percentage of the functional residual capacity).

Results: Comparisons with experimental measurements have been done for total, tracheobronchial (TB) and lobar deposition, showing good correlation between measured and simulated values. For instance, mean experimental TB deposition fraction in the left lung is 14.5 ± 2.4 , vs. 14.9 ± 4.1 for simulation results.

Conclusions: This work provides a scientific foundation for addressing both asymmetric and individualized lung morphologies in analytical modeling of aerosol deposition.

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Assessment of tumor size and movement trajectories using CT scans with different pitch settings

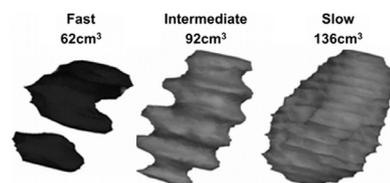
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Introduction: Pitch Settings of CT scanners have an influence on the way moving lesions are reconstructed. These images have an impact on target definition in radiotherapy planning, therefore the Planning-CT settings are of central importance for correct tumor irradiation and normal tissue sparing.

Method: A water filled 40mm table tennis ball serving as a tumor phantom was moved along an ellipsoid trajectory by a custom-assembled Lego(c) based device with a cycle duration of 4.2 seconds. The pitch/slice settings tested were termed "fast" (2.5mm, standard pitch), "fast" (2.5mm, half pitch), and "fast" (0.625mm, half pitch).

Results: The volume of the ball was overestimated with the volume of the tumor-phantom growing from 82% for the fast CT, 171% for the intermediate CT and 300% for the slow CT. The phantom trajectory could best be reconstructed in the slow CT. The different sizes can be seen here:



Conclusion: The custom lung phantom proved to work well for the specified task. The effect of CT settings during planning-CT acquisition on the resulting volumes was significant. Acquisition of slow-CT images for radiotherapy planning enables a better targeting of the moving tumor and sparing of normal lung tissue specifically when respiratory gating is not available.

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The role of polypositional CT in detecting adhesive process in the pleural cavity of TB patients under artificial pneumothorax (AP)

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We studied 54 patients with different forms of destructive pulmonary TB, which received artificial pneumothorax (AP) during 5.5 (± 1.5) months. Out of them 54.8% had infiltrative, 24.0% cavitary, 16.2% fibrocavitary, and 4.8% disseminated pulmonary TB. Sputum positive TB was established in 83.6% cases. Adhesive process in the pleural cavity was detected using polypositional computed tomography (CT). We developed the algorithm for radiographic monitoring of AP and detecting adhesive process in the pleural cavity. We established pleural adhesion in 70.3% cases; thoracocautic was performed in 52.6% cases, with 100.0% effectiveness of AP.

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In 47.4% cases thoracocautic was not administered to the patients with adhesive process; out of them 55.5% had effective AP, 16.6% – partially effective AP, and 27.9% – ineffective AP. Thus, polypositional CT demonstrated effectiveness in detecting adhesive process in the pleural cavity of TB patients.