recurrence in cervical cancer. Weighted PET parameters were less sensitive to the choice of threshold than standard parameters computed through hard-thresholding, all tested threshold TLG and MTV parameters becoming statistically predictive.

**PO-0929**

**Dual Energy CT imaging of tumour vasculature in NSCLC: an intra-patient comparison with DCE-CT**

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**Purpose or Objective:** Quantification of vasculature is frequently performed by dynamic contrast enhanced CT (DCE-CT) or MRI imaging. However, there are some limitations to this technique: DCE-CT requires a detailed kinetic fitting procedure, a prolonged acquisition time with increased dose to the patient, has a limited FOV and is not easy to implement in clinical routine. Dual Energy CT is an evolving field in CT image analysis that allows quantification of contrast material uptake using a single acquisition, making it easily implementable in a clinical workflow. Therefore we investigated the correlation between the DCE-CT derived vasculature parameters, blood flow and blood volume, with iodine related attenuation measured on a Dual Energy CT acquisition for non-small cell lung cancer patients.

**Material and Methods:** The same imaging protocol was followed for 13 patients on a Dual Energy CT scanner (Siemens Definition Flash). The protocol consisted of a Dual Energy CT scan (either 80/140kVp or 100/140kVp; 70 ml of iodine 300 mg/ml) of the entire thorax and a DCE-CT acquisition (65 ml of iodine 300 mg/ml; 33 frames @ 1.5sec for a total of 50 sec) in a 13 cm FOV centred around the primary tumour. Kinetic analysis was performed using commercial software (Siemens VPCT body) allowing the assessment of blood flow (unit: ml/100ml/min) and blood volume (unit: ml/100ml) in every voxel. Dual Energy CT images were analysed using in-house developed software for iodine contrast quantification. Iodine related attenuation was calculated by subtracting the Hounsfield units of the CT scan acquired at high energy from the scan acquired at low energy. A comparison was performed on 1) the entire tumour and 2) on a sub-volume level, defined by the upper 50% of the volume-of-interest. Correlation on tumour level was assessed by the Pearson correlation coefficient; overlap of sub-volumes with a DICE coefficient.

**Results:** There was a significant positive correlation between average contrast enhancement on Dual Energy CT and blood flow (r=0.615, p=0.025) and blood volume (average r=0.742, p=0.004) on a patient (i.e. tumour) level. Furthermore, the volumes defined by the highest 50% contrast enhanced uptake and 50% elevated perfusion coincided well (see Figure), with DICE scores of 0.72±0.10 (range 0.58-0.87) and 0.71±0.13 (range 0.50-0.91), for the blood flow and volume, respectively.

**Conclusion:** We observed high agreement between Dual Energy CT derived iodine enhancement and DCE-CT derived kinetic parameters, both on a tumour and sub-volume level. This may allow wider implementation of vasculature imaging of tumours using the simplified Dual Energy CT acquisition protocol.

**PO-0930**

**PET based response assessment of lung toxicity - assessment of two approaches for dose response**

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**Purpose or Objective:** Patients with lung cancer given external radiotherapy are at risk of radiation induced lung toxicity (RILT). In many studies, mean density changes from CT (in Hounsfield units) have been used as a surrogate for radiation-induced alterations in the lung. However, a combination of mean density changes from CT scans with corresponding standard deviations has been shown to be a more sensitive method. In the current work, we explore whether such a combined approach is feasible for 18F-FDG PET data as well.

**Material and Methods:** 13 patients with advanced non-small cell lung cancer, participating in a phase II trial on combined radiation and erlotinib therapy, were included. The patients were examined by 18F-FDG-PET/CT at three sessions; prior to, one week into, and six weeks after fractionated radiotherapy (3 Gy × 10). For each patient, lung was delineated in the planning CT images. The RT dose matrix was co-registered with the PET image series. For each PET image series, mean (μ) and standard deviation (σ) map were calculated based on cubes in the lung (3×3×3 voxels) and were further used to quantify local structure (S). The spread in μ and σ was characterized by a local covariance ellipse (in pre-therapy PET series) in a sub-volume of 3×3×3 cubes. The distance of individual cube values to the origin of the ellipse is then calculated using Mahalanobis distance method to form S maps. ΔS and Δμ maps are derived by subtracting pre-therapy maps from maps of mid- and post-therapy. A detection threshold was calculated based on three patients with two sets of pre-therapy PET scans who were not included in the study.

**Results:** The structure difference maps (ΔS) identified new areas of interest in the lungs of individual patients compared to the mean difference maps (Δμ) (Figure 1 A). On a population level, both ΔS and Δμ were significantly different (P<0.05) from the respective threshold level, irrespective of dose (Figure 1 B). The inter-patient relative variation in ΔS and Δμ were 57% and 88%, respectively, indicating that the ΔS approach yielded less heterogeneous results. 18F-FDG dose response was analyzed up to total dose of 15 Gy by first order linear regression. The relative slopes of the regression lines were 0.036, 0.018, 0.052, and 0.061 for Δμ (mid-pre), ΔS (mid-pre), Δμ(mid-pre), and ΔS (post-pre), respectively. A significant dose response was only seen for the ΔS taken between post and pre-therapy PET.
Dose-related neuronal changes were compared between the biologically effective doses to GTV ranged from 52 to 70 Gy. Each ROI thus encoded time-dependent MR parameters. The based on prior series of studies: visual or verbal, semantic or enabling patient-specific contours (ROIs) to be transferred. The following PRT. All MR images for each patient were co-

neuronal and white matter injury at 1.5, 6, 12 and 24 m

Apparent diffusion coefficient (ADC) and fractional anisotropy resonance imaging (MRI) and neurocognitive (NC) study. Conclusion: The new method based on local structures in 18F-FDG PET images was a feasible approach. This method is more sensitive in terms of providing a clearer 18FDG uptake dose response six weeks after initiation of treatment compared to standard image subtraction, and may be valuable in future studies addressing RILT.

PO-0931 Onset and recovery of neuronal injury following proton radiotherapy

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Purpose or Objective: To quantify the time course and the extent of radiation-induced neuronal changes following skull base (cohort I) or brain (cohort II) proton radiation therapy (PRT).

Material and Methods: We analyzed 4 cohort I and 4 cohort II patients, who completed 2 year follow-up magnetic resonance imaging (MRI) and neurocognitive (NC) study. Apparent diffusion coefficient (ADC) and fractional anisotropy (FA) from diffusion tensor imaging were used to evaluate neuronal and white matter injury at 1.5, 6, 12 and 24 m following PRT. All MR images for each patient were co-registered to the planning CT using rigid image registration, enabling patient-specific contours (ROIs) to be transferred. Each ROI thus encoded time-dependent MR parameters. The biologically effective doses to GTV ranged from 52 to 70 Gy. Dose-related neuronal changes were compared between the two cohorts as well as within each patient. Cohort I typically received a left-right symmetric PRT with higher dose to the temporal lobes and brainstem, and cohort II a unilateral PRT with a significant higher dose to only hemisphere. ROIs were hippocampus, cerebellum, corpus callosum, temporal lobes, GTV, brainstem and the whole brain. NC testing used 8 memory indices that are radiation-sensitive and insensitive, based on prior series of studies: visual or verbal, semantic or perceptual memory (encoding, retrieval, and reaction time to recognize).

Results: ADC is an inverse measure of cellular density. After PRT, average ADC first increased and then decreased; the peaks of the average ADC were detected at 1.5 m and 12 m after PRT for cohort I and II patients. Further, variations in the ADCs were correlated with the mean doses. This dose dependence had different temporal course between the two cohorts. For cohort I, the dose relationship disappeared 12 m after RT. For cohort II, the dose relationship was the strongest at 12 m after RT. \[ \Delta A D C / A D C (\% / G y) = [0.16, 0.15, 0, -0.06] \] and \[ [0.16, 0.19, 0.37, 0.09] \] at 1.5, 6, 12 and 24 m after PRT for cohort I and I.PA is a measure of neural connectivity in the brain. On average, no consistent changes in FA were observed for ROIs receiving a mean dose < 40 Gy. In ROIs that received > 40 Gy mean dose, FA decreased consistently. The largest reduction of FA was observed at 1.5 m following PRT. \[ \Delta F A / F A (\% / G y) = [0.16, 0.15, 0, -0.06] \] and \[ [0.16, 0.19, 0.37, 0.09] \] at 1.5, 6, 12 and 24 m after PRT for both cohorts. Among NC tests, only changes in verbal and visual semantic retrieval were significant. Decline occurred 1.5 m after PRT (visual semantic reaction time: \( p<0.005 \); verbal semantic retrieval: \( p<0.000 \)). Recovery occurred 6 m after PRT, and reached baseline at 24 m.

Conclusion: ADC and FA are sensitive measures to quantify radiation-induced neuronal injury following PRT. Both ADC and FA showed changes at 1.5 m and a recovery similar to the time course of changes in NC functions.

Poster: Physics track: Images and analyses

PO-0932 Preliminary clinical study to evaluate an interactive system to segment OARs in thoracic oncology

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Purpose or Objective: Radiotherapy aims at delivering the highest possible dose to the tumor while minimizing the irradiation of surrounding healthy tissue, and especially to the organs at risk (OARs). Therefore, accurate delineation of OARs is required for radiation treatment planning (RTP). In thoracic oncology, delineation of some OARs remains manual, making the task time consuming and prone to inter observer variability. Various (semi-) automatic approaches have been proposed to segment OARs on CT but the task still remains challenging. Here, a system to interactively segment OARs in thoracic oncology on CT images is presented and its clinical acceptability evaluated.

Material and Methods: The proposed framework has been implemented using MITK platform. User interaction lies in the easy definition of few manual seeds for the OARs and background using a ‘paintbrush’ tool, which can be interactively added in any view (axial, sagittal or coronal), and is subsequently propagated within the whole volume. Once the user is content with the seeds placement, the system automatically performs the segmentation. If the outcome is not satisfying, the user can modify the seeds, which involves adding and/or removing existing seeds, and perform again the automatic segmentation. Number of tries has been limited to five in the current study. If after the five modifications the segmentation result is not sufficient to be usable in the RTP, the user shall reject it; otherwise, he shall accept it. A hybrid approach combining watershed transformation and graph cuts is used for the segmentation task.