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Free-breathing dynamic contrast enhanced MRI of lung cancer
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Purpose or Objective: Dynamic contrast enhanced (DCE) MRI is becoming an increasingly important tool for assessing tumour response in Radiotherapy (RT). Important characteristics are spatial and temporal resolution and in lung this is further complicated by the effects of respiratory motion. A common approach is to acquire fast gradient-echo imaging utilising k-space sharing to provide optimum temporal resolution and to collect data during short ‘windows’ of breath-holds over the time course. However patient compliance during breath hold manoeuvres can lead to tumour displacement and introduce error in analysis. Radial acquisitions can alleviate motion by oversampling the centre of k-space albeit with reduced temporal resolution. The purpose of this study was to evaluate whether such a ‘stack-of-stars’ acquisition can be used with high enough resolution for the DCE sequence to provide a complete free breathing RT planning protocol in lung patients.

Material and Methods: Institutional review board approval was obtained. Two patients receiving lung radiotherapy underwent DCE-MRI on our dedicated wide bore 3 Tesla system (Skyra, Siemens) using an 18 channel flexible coil and 32 channel table coil. Patients were positioned as per treatment setup with their hands above their head. Two DCE protocols were examined; a fast gradient-echo sequence employing k-space sharing (TWIST) acquired as 5 breath-hold periods of 20s each with a spatial and temporal resolution of 1.5 mm/3 s; and a completely free breathing scan performed using a radial acquisition (StarVIBE) with a resolution of 1.8 mm and 14 s. The acquisition time was approximately 6 minutes for both sequences. In both cases a rapid pre-contrast measurement of T1 was acquired using the same sequence and two flip angles. Analysis included calculation of T1 map and a two-compartment model fit to the data (Tissuee4D, Siemens) to provide pixel-by-pixel maps of the perfusion rate constant.

Results: Figure 1 shows images and analysis taken from both sequences. Viewing DCE data in a cine loop revealed large movement between frames for TWIST compared to StarVIBE. A comparison of signal-time plots shows a typical result where failure to maintain and reproduce breath hold has produce large variation and discontinuities in the dataset. As a result the goodness-of-fit (chi2) was better for StarVIBE (0.05) than the corresponding value using TWIST (0.16). Although temporal resolution is much poorer with the StarVIBE sequence, it was sufficient to sample the early upslope phase of the contrast agent. General image quality was assessed with radial and motion artefacts scored as being negligible.

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Are planning CT radiomics and cone-beam CT radiomics interchangeable?
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Purpose or Objective: Radiomic image features derived from conventional treatment planning CT images have already been shown to have prognostic information. For cone-beam CT (CBCT) imaging during radiotherapy this has not yet been described. Due to the fact that a CBCT image is acquired prior to each fraction it has the potential to monitor response to treatment. The goal of this study was to investigate the stability and the correlation between radiomic features derived from planning CT vs. CBCT and between CBCTs of different fractions.

Material and Methods: A total of 27 stage II-III NSCLC patients who received radiation therapy were included in this study. For each patient a treatment planning CT scan was acquired and CBCT scans were obtained prior to each fraction. The planning CT (CT1), the CBCT of the first (CBCT-FX1) and second fraction (CBCT-FX2) were used in this study. CBCT images were registered to CT1 using automatic rigid registration prior to feature extraction. In total, 149 radiomic image features were extracted from different feature groups: i) tumor intensity, ii) texture, iii) Laplacian of Gaussian. The third group consists of filtered first order features and the group was subdivided into 10 groups, according to different LoG filter standard deviations ranging from 0.5 mm to 5 mm with a 0.5 mm interval. Since a rigid registration was used, features related to shape and volume were not analyzed. The correlation between features derived from (1) CT1 and CBCT-FX1 and (2) CBCT-FX1 and CBCT-FX2 were analyzed. Correlations were calculated using an intraclass correlation coefficient ICC(2,1). An ICC-value above 0.9 was considered a good agreement.

Results: For 26% of the 149 analyzed radiomics features, the ICC-value was higher than 0.9 for CT1 compared to CBCT-FX1 (Figure). The ICC-value was above 0.9 for 81% of the features when comparing CBCT-FX1 to CBCT-FX2. Specifically for the feature group ‘texture’, one of the 44 features had an agreement between CT1 and CBCT-FX1 that was higher than 0.9, but 35 out of 44 did show agreement for CBCT-FX1 vs. CBCT-FX2. For ‘tumor intensity’, 2 out of 15 features showed a large correlation between CT1 and CBCT-FX1 higher than 0.9, whereas 10 out of 15 features showed agreement higher than 0.9 between CBCT-FX1 and CBCT-FX2 (ICC>0.8 for all). All features with ICC above 0.9 for CT1 vs. CBCT-FX1 also showed high correlation between CBCT-FX1 and CBCT-FX2.

Conclusion: These initial results show that use of a radial k-space trajectory as a method of motion compensation provides a DCE scan of sufficient image quality and temporal resolution which can be used as part of a complete free breathing lung protocol.