FRACTAL DIMENSIONS OF NON-SMALL CELL LUNG CANCER ON CT PREDICTS FDG-PET STAGE AND UPTAKE

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Revealing the Invisible is Possible

Being able to extract useful otherwise hidden information through digitally processing medical images is an important tool for physicians to support accurate diagnosis without the need for biopsies — a process that can be unpleasant for patients and requires time, effort and incurs additional costs. The ability to predict the type of tumour and uptake on fluorodeoxyglucose positron emission tomography (FDG-PET) with good accuracy from CT image would be very advantageous.

Fractals as a texture measure

Fractals are used to describe non-Euclidean structures that show self-similarity at different scales. Given that most biological and natural features show discontinuities and fragmentation so they tend to have a fractal dimension (FD).

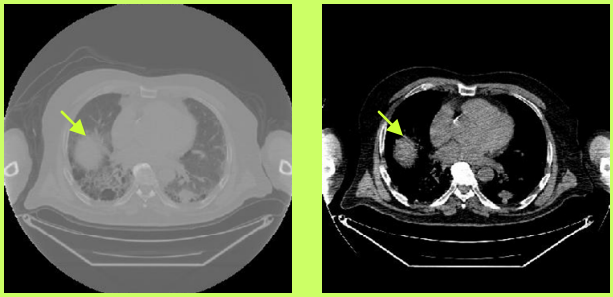
$$FD = log(N_k)/log(1/k)$$

where N_k is the number of self-similar shapes and k is the corresponding scaling factor.

This study investigates whether the FD of non-small cell lung cancer (NSCLC) on CT predicts tumour stage and uptake on fluorodeoxyglucose positron emission tomography (FDG-PET).

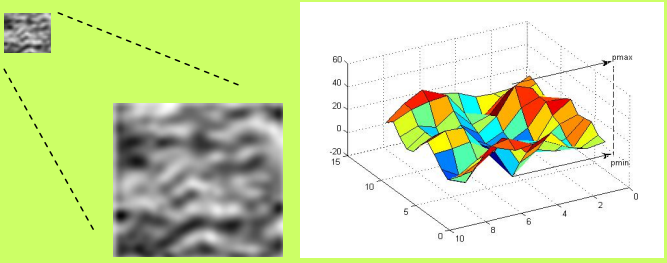
Methods

2mm thick CT images of primary tumour were obtained from PET-CT studies of 56 patients with NSCLC. The FD within a tumour region was determined on a pixel-by-pixel basis using a box counting (BC) algorithm and compared to the nodal (N), metastatic (M) and overall stage determined from PET. FD was also correlated with the maximal (FDG_{max}) and average (FDG_{avg}) tumour uptake of FDG.



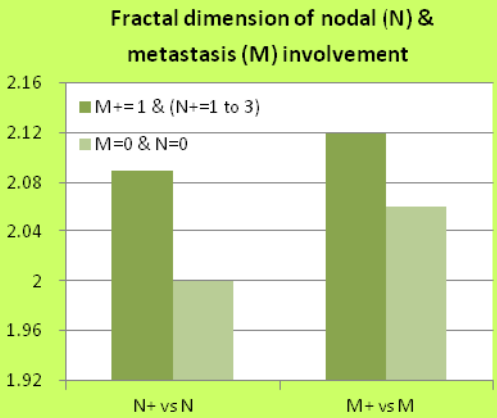
Original CT image (left) and a windowed FD transformed version (right) to facilitate the region of interest (ROI) extraction as the tumour becomes more separated from surrounding structure.

The figure to the left bellow shows a stage IB lung tumour region of interest (ROI) enlarged to show texture, and beside it a 2D surface image showing the max and min peaks which will be used in the BC algorithm to estimate the FD. This work shows that examining the fractal characteristics of texture structure variation could assist in determining the relative stage of the examined ROI.



Results

There was a significant correlation between tumour FD and overall stage (Spearman Rank Correlation: r= 0.5831, p= <0.0001). The Mann-Whitney U test for the FD values were significantly higher in N+ (2.09 vs 2.00, p_N = 0.0139) and M+ (2.12 vs 2. 06, p_M = 0.0194). FD also correlated significantly with FDG_{avg} and FDG_{max} (r=0.3732, 0.4294 &, p=<0.005, < 0.001 respectively).



Conclusion

Higher FD in CT images of NSCLC is associated with advanced stage and greater FDG uptake on PET. Measurements of tumour FD on conventional CT examinations could potentially be used as a prognostic marker and/or to select patients for PET. Application of this method to other imaging modalities is being investigated.

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