**Idiopathic pulmonary fibrosis: a study using volumetric imaging and functional data in a computational lung model**

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**Introduction**

Idiopathic pulmonary fibrosis (IPF) is the most aggressive and frequent form of idiopathic interstitial pneumonias with unknown cause. It is a lethal fibrosing lung disorder that occurs primarily in middle-aged and elderly adults. The progression of IPF is variable between individuals and no established quantitative tools exist to indicate the likely progression of the disease. The aim of this work is to develop a new quantitative method of the IPF that integrates information from volumetric imaging, pulmonary function tests, and computational models for lung function; and to conduct a quantitative assessment of IPF tissue characterisation and disease development over time in comparison to normal adults of the same age.

**Method**

Tissue regions in HRCT images from 8 patients with IPF (aged 43-82) were quantitatively analysed. In the IPF cohort tissue abnormalities were classified using CALIPER (Computer-Aided Lung Informatics for Pathology Evaluation and Ratings) software. Mean tissue density (TD), volume and spatial distribution of ...were calculated. The classified data were mapped to a statistical shape model, which allows consistent comparison between patients or within one patient at different time points. A computational representation airway tree was generated for each individual patient and deformed to fit the lung shape of each time point. A principal component analysis (PCA) and fractal dimension was applied to assess lung shape and tissue heterogeneity differences between IPF lungs andnormal aging lungs. These quantitative tissue biomarkers combined with pulmonary functional tests were used to drive a non-uniform tissue property (density, stiffness, resistance and compliance) based stress distribution analysis and gas exchange simulation of IPF lung.

**Result**

Fibrosis usually has consistently higher TD (0.34/0.41 for reticular/ground-glass) compared to normal tissue (0.28), and presents predominantly in lower lobes basally and peripherally. In contrast, emphysema has lower density (0.08) and appears predominantly in upper lobes. Most IPF patients experience a decrease lung volume (11.85% off averagely within n 5-20 months). The lung shape between IPF lung and old normal ones is significant different in the first mode of PCA analysis (p-value is 0.001) which captures over 20% of shape variation. There is a strong correlation between stress distribution and the distribution and development of disease (elastic recoil pressure of fibrosis is higher than normal whereas emphysema is lower). V-Q mismatching and impaired gas exchange occurs in IPF lungs even in CT evaluated ‘normal’ tissue.

**Conclusion**

An image based analysis of IPF tissue characterisation and distribution combined with functional modelling techniques provides a set of tissue-level markers of IPF. This could be a potential tool to help with assessment of IPF progression at the early stage of this disease.