Multi-nuclear MRI lung volumetry

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ABSTRACT

Purpose
Recent developments in fast imaging sequences have led to a renaissance in proton lung MRI. Hyperpolarised noble gases in MRI imaging have led to a rapid evolution of technique. One application of this new technology is the quantification of ventilated lung volumes. This thesis examines the practicalities involved in measuring lung volume using both modalities.

Materials & Methods
A systematic review was conducted of the evidence of validity, reliability, and patient toleration of MRI lung volumetry. Phantoms were imaged to evaluate the reproducibility and reliability of image segmentation for both methods. Healthy volunteers and patients were imaged upon multiple occasions to evaluate reliability and validity. Patients with COPD, Lung Cancer, CF and Asthma were imaged using a combination of ^{3}He MRI and Proton MRI. The safety and physiological effects of the hypoxic breathing manoeuvre were assessed.

Results
^{3}He ventilation MRI is increasingly being used to probe the lungs in specialist centres, and proton MRI has also been used in the calculation of lung volumes. Each technique showed good correlations with current “gold standards”. Both segmentation methods provided an accurate measurement of volume in the phantom. All methods of image segmentation had good intra-observer reproducibility, with a semi-automated threshold method being the preferred method for the segmentation of ^{3}He images. Lung volumes were calculated for all patient groups. Reductions in ventilated volume were demonstrated in COPD patients and healthy smoking volunteers. Reversibility of asthma measured by ^{3}He volumetric changes correlated well with spirometric indices. Regional ventilated volumes were calculated in both asthmatic and CF populations, and post treatment effects were demonstrated in asthma, CF and lung cancer patients ^{3}He was applied using two different methods in 111 subjects with no ill effects, and only transient desaturations observed.

Conclusion
Combined ^{3}He / Proton volumetric imaging correlates well with established diagnostic measures, is safe, highly reproducible and provides added regional information.