Imaging V/Q in Chronic Thromboembolic Pulmonary Hypertension with ^{3}He and ^{1}H MRI

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Rationale In Chronic Thromboembolic Pulmonary Hypertension (CTEPH) the pulmonary vascular bed is obstructed by organised thrombus and patients can potentially be cured by surgery (pulmonary endarterectomy) if the disease is surgically accessible [1]. CTEPH is often initially suspected due to wedge-shaped perfusion defects using ventilation-perfusion scintigraphy [2] but the images have limited spatial resolution and use ionising radiation. CTPA gives more detailed spatial resolution of the vasculature but also uses ionising radiation. MR angiography and perfusion imaging are increasingly used to assess perfusion in CTEPH [3] but ventilation imaging is usually limited to scintigraphy. Previously ^{3}He and ^{1}H MRI has been used to image V/Q in pulmonary embolism patients [4] and showed promising results.

Here preliminary results using ^{3}He ventilation and ^{1}H perfusion MRI to image V/Q matching in CTEPH patients are presented.

Methods: Six CTEPH patients were scanned using a 1.5T whole body MRI system (GE HDx, Milwaukee, WI). One patient was scanned both pre and post pulmonary endarterectomy.

Ventilation Images: Patients were positioned in a ^{3}He transmit-receive vest coil (Clinical MR Solutions, USA). A mix of 300ml of hyperpolarised ^{3}He (25% polarisation) and 700ml of N_2 was inhaled, and ^{3}He ventilation images were acquired at breath-hold (full lung coverage, 3x3x10mm spatial resolution, θ=7°).

Perfusion Images: Patients were repositioned in an 8-element ^{1}H cardiac coil (GE, Milwaukee, WI). Contrast-enhanced perfusion data were acquired at inspiratory breath-hold with full lung coverage, 2.4x6x10mm spatial resolution, 0.5s temporal resolution, 0.05ml/kg of Gadovist at 4ml/s, and 20ml saline flush at 4ml/s.

Perfusion images were registered to the ventilation images using a landmark-based rigid registration (Drop3 software, [5, 6]). V/Q ratio and V-Q intersection maps were generated in Matlab (Natick, MA).

MR angiography and perfusion scintigraphy data were also acquired from each patient.

Results: Figure 1 shows perfusion scintigraphy images for patient 1 pre-endarterectomy.

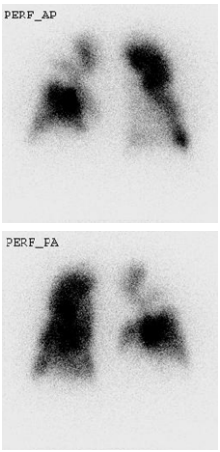

Figure 1: Q scans

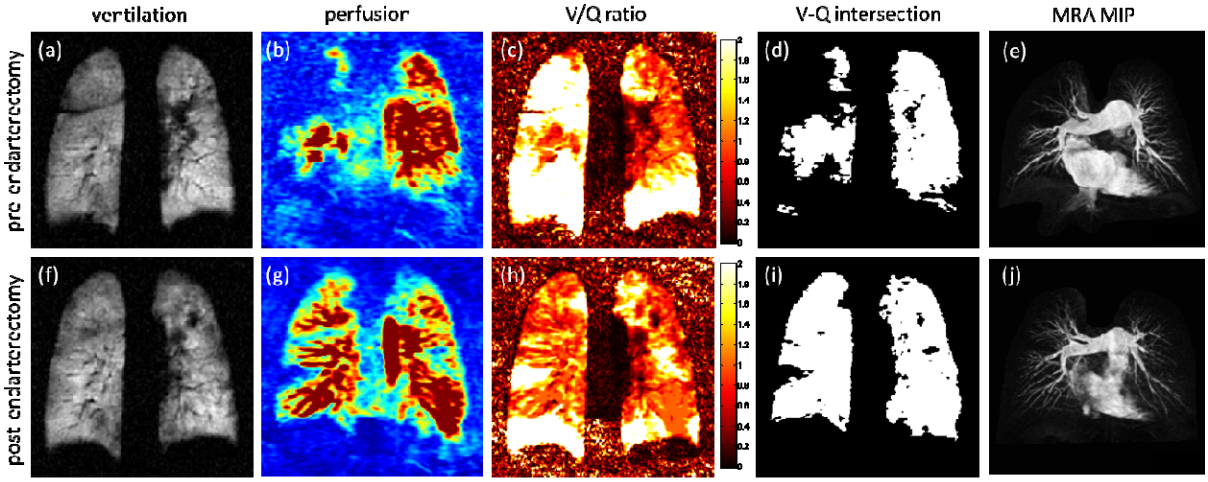

Figure 2: images from patient 1, pre (top row) and post (bottom row) endarterectomy

Figure 2 shows MR images from patient 1 pre and post endarterectomy. The patient's lungs were generally well ventilated throughout (a, f) and the perfused lung volume (b, g) was greatly increased by the endarterectomy. The V/Q ratio (c, h) and V-Q intersection maps (d, i; lung tissue which is both perfused and ventilated) help to visualise which regions are taking part in gas exchange. MRA MIP images (e, j) also show improved vessel patency post-endarterectomy.

Discussion: The MR images have substantially higher spatial resolution than ventilation-perfusion scintigraphy, and therefore ^{3}He ventilation MRI may be able to provide unique information about the disease process. The method can be sensitive to mis-registration near the diaphragm if the lungs are at different levels of inflation in the ^{3}He and ^{1}H datasets. The non-ionising nature of V/Q MRI makes it particularly suitable for repeat studies monitoring patient response to interventions.

Conclusions: ^{3}He ventilation and ^{1}H perfusion MRI are useful for the assessment of ventilation and perfusion distributions in CTEPH patients, and could act as a sensitive non-ionising means of therapy follow up.

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References: [1] European Heart Journal 30(20):2493-2537 (2009); [2] Pepke-Zaba, Eur Respir Rev 19(115):55-8 (2010); [3] Kreitner et al, Eur Radiol 17:11-21 (2007); [4] Lipson et al, MRM 47:1073-1076 (2002); [5] Glocker et al, Med Image Anal 12(6):731-41 (2008); [6] Komodakis et al, proc IEEE CVPR (2007).