Time-Resolved Pulmonary MR Angiography and Perfusion Imaging at 3.0 T; Initial Results with Echo-Sharing and Parallel Acquisition.

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Purpose: To assess the feasibility of dynamic pulmonary MRA and perfusion imaging at 3.0 T, using echo-sharing and parallel acquisition with a phased array body coil

Materials and Methods:

12 adult healthy consecutive volunteers and 3 patients with pulmonary hypertension (12 M, 5 F, 29-87years old) were imaged on a whole body 3.0 T system (Siemens Magnetom Trio) using a technique based on a fast 3D GRE **(1)**, which incorporated GRAPPA **(2)** and echo-sharing to further improve performance. Sequence parameters were: TR/TE= 2.2/1 ms; FA=20º; FOV=380 mm; slice thickness=9mm; 16 partitions; matrix: 320x240; voxel size= 1.7x1.2x9 mm^3; BW=1300Hz/pixel; GRAPPA acceleration factor 2. Following injection of 6 ml gadodiamide (Omniscan, Amersham Health Inc.) at a rate of 4 ml/s, a coronal 3D data set was acquired every 1.9 seconds for 22 seconds, during breath-holding. Magnitude subtraction, in the image domain, of the first (unenhanced) data set from all subsequent data sets was performed online, as was on-axis MIP reconstruction.

For qualitative assessment pulmonary arterial (PA) and paranchymal enhancement (PE) phases were selected from the subtracted data sets. Once chosen, coronal thin MIP (8 mm by1 mm) images were prepared and reviewed throughout the volume. Pulmonary arterial branches were evaluated to the highest order visualized. Each branch was scored on a 1-5 scale scoring system (marginal 1; fair 2; good 3; very good 4; excellent 5) based on quality and vessel definition. PE was scored on a 1-4 scale (poor 1; fair 2; good 3; excellent 4) for the visibility of parenchymal enhancement, lung fissures, and delineation from adjacent chest wall and pulmonary vessels.

For quantitative assessment, region of interests (ROIs) were placed over the lungs and signal intensity versus time-curves were obtained using dedicated software (MERZ, Siemens Medical Solutions). The software uses a gamma variate fit to derive perfusion parameters on a pixel by pixel basis and calculates mean transit time (MTT), time to peak (TTP), maximal signal intensity (MSI), and maximal upslope of the curve (MUS). A paired t test was used to evaluate the significance of differences between normals and pulmonary hypertension patients.

Results:

All studies were performed successfully. Up to 4th order pulmonary artery branches were visualized in all subjects (100%) with good definition (mean = 3.46). Parenchymal enhancement was identified in all subjects with a mean score of 3.1. Quantitative analysis showed mean TTP: 4.4 ±1.1, MTT: 7.3 ± 1.3, mean MSI: 368 A.U, and mean MSU: 137.7 A.U/s. In the pulmonary hypertension patients, the following perfusion parameters were calculated: TTP=7.1, MTT=10, MSI=138.2 MSU=34.3, all with statistically significant differences from the volunteers ($p<0.001$).

Figure 1 & 2 show representative examples of time resolved MRA, and color-coded perfusion map respectively.

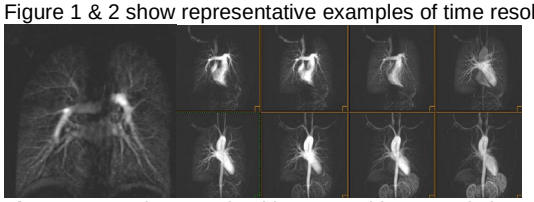

Figure-1. 3D, time-resolved images, with a sample interval of 1.9 secs, show sequential filling of pulmonary arteries, pulmonary parenchyma and systemic arteries.

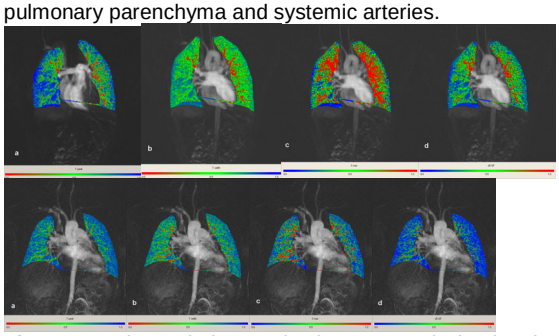

Figure-2. Color-coded map of pulmonary perfusion in a healthy volunteer (upper row) and a patient with pulmonary hypertension (lower row): TTP (a), MTT (b), MSI (c), MUS (d)

Conclusion:

Time-resolved 3D pulmonary MRA and perfusion imaging is feasible at 3.0 T **(3)**. Quantitative analysis of dynamic enhancement data yielded multiple parameters and color-coded maps which correlate well with established physiological norms. Initial results show detectable abnormalities in patients with pulmonary hypertension. Further studies are indicated to establish the clinical applications and the accuracy of this technique in a clinical setting.

References:

1. Finn JP, et al. Radiology 2002.
2. Griswold et al. MRM 2002.
3. Carr JC, et al. ISMRM Proceeding 2004.