Comparison of two Gadolinium contrast agents for lung perfusion MRI

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Introduction: With the development of faster imaging sequences, MR contrast enhanced lung perfusion imaging has become feasible in the clinical setting and shows great promise as a non-ionizing alternative to a nuclear scintigraphy lung perfusion scan. In this work, a visual and quantitative comparison is made between perfusion maps of the lung acquired using two different gadolinium-based paramagnetic contrast agents.

Methods: Five patients with Chronic Thromboembolic Pulmonary Hypertension were recruited into the study. Patients underwent a protocol that included two separate perfusion imaging acquisitions; the first using Magnevist (0.5 molar Gd-DTPA) and the second (acquired < 48h later) with Gadovist (1.0 molar Gd-BT-D3OA) as the contrast agent. Each patient was administered a constant contrast agent dose of 0.2 mmol/kg at 5ml/s from a power injector (Medrad), i.e. half the volume of Gadovist in half the time, compared to Magnevist. The perfusion imaging was performed on a 1.5T system (Philips, Eclipse) using the same imaging sequences for each contrast agent: Time-resolved 3D MRA, TR / TE = 3.2 / 0.95 ms, α = 30º, 16 slices, Thk = 10mm, Matrix = 256 × 256, FOV = 450 × 450 mm. The image acquisition was repeated 10 times during a single breath-hold with a temporal resolution of 2.0s. Images were transferred in DICOM format to a standard PC workstation and processed using in-house software written in C. Processing consisted of voxel-by-voxel estimation of contrast agent concentration at each time point t using the standard formula [1], $C(t) = -(k / TE) \ln[S(t) / S(0)]$, and then gamma-variate curves were fitted to the estimated concentration-time curves at each voxel. Relative measures of pulmonary blood volume (PBV) were estimated from the area under the fitted curve, pulmonary transit time (PTT) as the first moment of the curve and pulmonary blood flow (PBF) was calculated from $PBF = PBV / PTT$. In addition, the full width at half maximum (FWHM) of the curve was also measured. Images of PBV, PTT, PBF and FWHM were then stored in Analyze format and region of interest (ROI) measurements obtained from the pulmonary arteries, left and right lung in a representative slice of each patient using Analyze 7.0. The image processing was repeated identically for both the Magnevist and Gadovist datasets. The ROI measurements were compared between left and right sides of the lung by calculating the percentage difference (PD) between the two sides, where $PD_A = [(A_L - A_R) / A_R]*100$ and A represents either PBV, PTT, PBF or FWHM and the subscript L or R indicates the side. The overall mean PD_A for each contrast agent was then calculated by averaging from all patients and a paired student's t-test was used to compare PD_A between the Magnevist and Gadovist derived data for each of the four measured parameters.

Results: Of the five patients, all had successful Magnevist perfusion scans, while only four had complete perfusion datasets with Gadovist, due to a patient reaction (nausea) to Gadovist. The four patients (3 female, 1 male, mean age 63 ± 5 yrs) having complete datasets with both contrast agents had ROI measurements taken from both lungs and the results are shown in Table 1. These indicate that there is no significant difference between the observed magnitude difference of the perfusion metrics derived from either Magnevist or Gadovist. The overall mean PD_A is very similar for the two contrast agents for all metrics, with a slight (but insignificant) trend towards a greater difference in metrics derived from Gadovist. Furthermore, visual inspection of the images revealed no obvious difference in the quality of the images obtained from the two different contrast agents, with both highlighting regions of pathology to a similar degree (Fig. 1). Interestingly, no difference was observed in the PTT measured from the pulmonary arteries between the two contrast agents with PTT = 5.6 ± 1.0 s for Magnevist and PTT = 5.4 ± 1.0 s for Gadovist.

Patient	Contrast Agent	PTT	PBF	PBV	FWHM
1	Magnevist	-17 %	36 %	18 %	-26 %
1	Gadovist	-16 %	37 %	16 %	-21 %
2	Magnevist	-21 %	38 %	14 %	-9 %
2	Gadovist	-32 %	90 %	47 %	-31 %
3	Magnevist	-2 %	40 %	33 %	-10 %
3	Gadovist	2 %	-11 %	-5 %	7 %
4	Magnevist	7 %	1 %	6 %	7 %
4	Gadovist	4 %	21 %	25 %	4 %
AVE	Magnevist	-8 %	29 %	18 %	-10 %
AVE	Gadovist	-10 %	34 %	21 %	-10 %
TTEST	Mag-Gad	p = 0.59	p =0.82	p =0.86	p =0.96

Table 1: Percentage changes in PTT, PBF, PBV and FWHM observed between left and right lungs in four patients scanned with both Magnevist and Gadovist.

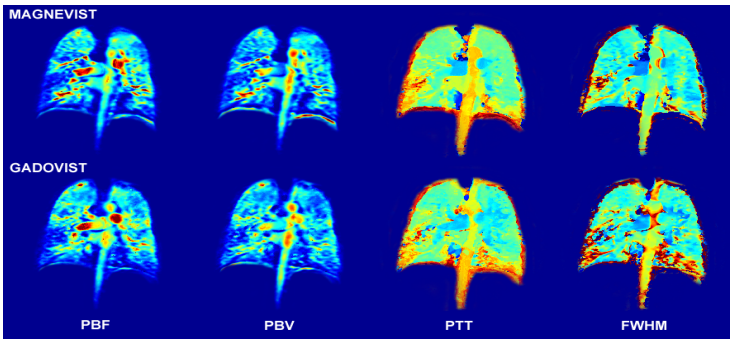

Figure 1: Representative lung perfusion images (Patient 1) showing from left to right PBF, PBV, PTT and FWHM, obtained using Magnevist (top) and Gadovist (bottom).

Discussion: There appears to be very little difference, either visually, or quantitatively, between the perfusion data obtained using Magnevist or Gadovist. There was also no difference observed between the arterial input widths as measured by the PTT in the pulmonary arteries, suggesting that any benefit of the shorter administered bolus is lost during passage through the venous system from the injection site, probably exacerbated by the poor right ventricular function of this patient group. Furthermore, the bolus width may also be erroneously represented by the present methodology if there is a complex non-linear susceptibility effect.

Conclusion: Both Magnevist and Gadovist are capable of creating good quality, diagnostically useful lung perfusion images in patients with Pulmonary Hypertension when the patient is compliant. The increased molarity of Gadovist seems to offer no advantage or disadvantage in perfusion imaging at 1.5 T, whereas in previous studies of high resolution 3D lung MRA of the pulonary vessels increased contrast to noise ratio have been observed [2].

References: [1] Ostergaard L, et al. *Magn Reson Med* 1996;36:726-736. [2] Woodhouse N, et al. *Proc ISMRM* 2006; 1956.