Do high molarity contrast agents improve cerebral perfusion imaging at 3T?

O. Thilmann[1], E-M. Larsson[2], I. M. Björkman-Burtscher[2], F. Ståhlberg[1,2], R. Wirestam[1]

[1]Department of Medical Radiation Physics, Lund University, Lund, Sweden, [2]Department of Radiology, Lund University Hospital, Lund, Sweden

Introduction

The introduction of high-molarity contrast agents combined with the increasing availability of high field scanners promises for an improved quality of calculated perfusion maps in dynamic susceptibility contrast MRI. A preceding study [1] indicated that to obtain the best possible concentration-to-noise ratio, a short echo time in gradient-echo EPI should be applied. In the present study the effects of different contrast agents and doses are compared in order to evaluate possible advantages of high-molarity agents and to determine the optimal combination of contrast agent and dose. Similar studies have been done at 1.5T [2] and applicable simulations have been performed [3], but to the best of our knowledge, no in vivo evaluation has yet been conducted at 3T.

Material and Methods

A total of 16 healthy volunteers (age 20-25y, mean 23y, weight 58-81kg, mean 70kg) each received single dose (0.1 mmol/kg bodyweight) and double dose (0.2mmol/kg bw) Gadovist (Schering, 1.0M) and a single dose MultiHance (Bracco, 0.5M) in three examinations, separated by a minimum of 72 hours to ensure complete excretion of the contrast agent. MRI was performed on a 3T head scanner (Siemens Magnetom Allegra). The applied perfusion weighted GRE-EPI sequence recorded 20 slices of 5mm thickness with a repetition time of 1.5s over a total of 90s. Imaging parameters were acquisition matrix 72x128, imaging matrix 128x128, TE=21ms, and field of view 210x210mm^2. The contrast agent was injected at a rate of 5ml/s, followed by a 40ml saline flush. T1 and T2 weighted images with identical geometrical parameters were also acquired and evaluated to exclude possible inclusion of pathological lesions. For analysis, four regions of interest (RoIs) in grey matter (lentiform nucleus, thalamus, insular and occipital cortex) and two in white matter (frontal and parietal) were defined in both hemispheres. For these RoIs, relative signal decrease and SNR_c[4], i.e. the signal-to-noise ratio of the concentration curve at maximum concentration as defined in Eq. 1, were evaluated. Relative regional cerebral blood flow (rCBF) and cerebral blood volume (rCBV) maps were then calculated using software developed within the research group. The same RoIs as above were applied to calculate grey matter/white matter blood volume and flow ratios and grey matter/white matter contrast (CTR) as defined in Eq.2. rCBF parametric maps were assessed with respect to their diagnostic suitability [satisfactory/not satisfactory] and general image quality by two experienced radiologists who were blinded with respect to contrast agent and dose.

$$SNR_c = SNR \cdot \frac{S_{\min}}{S_0} \cdot \ln\left(\frac{S_0}{S_{\min}}\right) \qquad Eq.1$$

$$CTR = \frac{rCBF_{GM} - rCBF_{WM}}{rCBF_{GM} + rCBF_{WM}} \qquad Eq.2$$

Results

Single dose Gadovist and single dose MultiHance showed comparable results within error margins in all assessed parameters. Image series acquired with double dose Gadovist showed on the average a 60% higher relative signal drop than single dose measurements. However, bolus width (FWHM) proved to be nearly identical for all the three cases in artery as well as in grey and white matter. Figs.1a and 1b display calculated SNR_c in grey matter and white matter for the three cases, averaged over all RoIs and all volunteers, error bars display the standard error of the mean. SNR_c was significantly higher for Gadovist double dose than for single dose examinations in GM and WM (paired t-test, $p < 0.001$). Grey matter/white matter rCBF ratios and contrast were equal within error margins for all three doses. Fig.2a shows the grey matter/white matter ratio, Fig.2b the corresponding contrast as defined in Eq.2 for the RoIs set in the thalamus (GM) and combined WM RoIs. The suitability for diagnostic purpose was without exception rated satisfactory. When evaluating rCBF overall image quality with respect to contrast, blurriness and delineation of anatomic structures, maps generated from double dose examinations were judged superior to single dose examinations in all cases (Table 1).

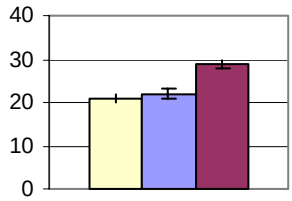

Fig 1a: GM SNRc

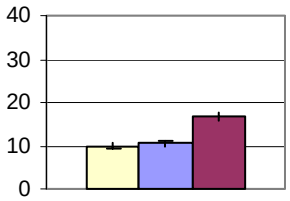

Fig 1b: WM SNRc

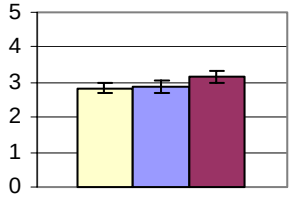

Fig 2a: GM-WM ratio

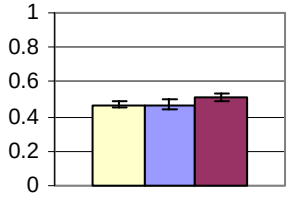

Fig 2b: CTR

Figs 1a-2b: Order from left to right in all figures: MultiHance single dose, Gadovist single dose, Gadovist double dose. Error bars show calculated standard errors of the mean.

Discussion

The nearly identical FWHMs for all measured signal curves indicate that the bolus shape is independent of injection volume and contrast agent molarity and depends only on blood circulation and cardiac output. This is in contrast to earlier findings [2], most likely due to the large injection volume resulting from the high dose of 0.3 mmol/kg bw used in [2], but it agrees well with simulations [3]. While the concentration-to-noise ratio was significantly higher for the double dose examination, the quantitative RoI analysis of parametrical images shows comparable results for all doses and contrast agents in all assessed values. In the qualitative evaluation of rCBF maps, double dose gadolinium examinations were clearly rated superior to single dose examinations. However, given the similar shape of the bolus, this finding has rather to be attributed to the higher contrast agent dose than to its higher molarity. Regarding the clinical value, rCBF maps from all contrast agents and doses investigated were rated as being satisfactory for diagnostic purposes at 3T.

Dose 1	superior to	equal to	inferior to	Dose 2
Gadovist dbl.	16	0	0	Gadovist sgl.
Gadovist dbl.	16	0	0	MultiHance sgl.
Gadovist sgl.	10	1	5	MultiHance sgl.

Table 1: Qualitative comparison of the calculated rCBF images for the different applied contrast agents and doses

Acknowledgments

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References

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