Pseudo-Continuous Arterial Spin Labeling quantification errors in the obese population

Dennis F Heijtel[1], ElsMarieke van de Giessen[2], Matthan W Caan[1], and Aart J Nederveen[1]
[1]Radiology, Academic Medical Center, Amsterdam, Netherlands, [2]Nuclear Medicine, Academic Medical Center, Amsterdam, Netherlands

Introduction

With the increasing obese population knowledge of the different pathology changes involved in this patient population, has become a major research subject. It has been shown that obese patients (Body Mass Index (BMI) larger than 30) present distinct functional activity patterns in selected brain regions, compared to normal weight subjects [1]. The cerebral blood flow (CBF) is an important parameter in the assessment of different cerebrovascular pathologies. Combined with the difficulty to perform contrast enhanced perfusion imaging in the obese population, Arterial Spin Labeling (ASL) would be the preferred method of choice for perfusion imaging. Due to the non-invasive character of ASL, complications due to incorrect contrast dosage calculations are less likely. However, an important barrier for MRI imaging in the obese patient population is the limited size of the MRI bore compared to the size of the patient. With the arrival of low field open bore MRI scanners and high field wide bore MRI scanners, the possibility to study the pathology in the obese patient population, has increased substantially. Since an increased neck volume is expected in the obese population compared to the normal weighted population, it is suspected that variations in labeling efficiency might be of more importance in ASL quantification of obese subjects. Therefore the aim of this study is to assess the obese population specific influence of different labeling efficiency strategies on ASL quantification.

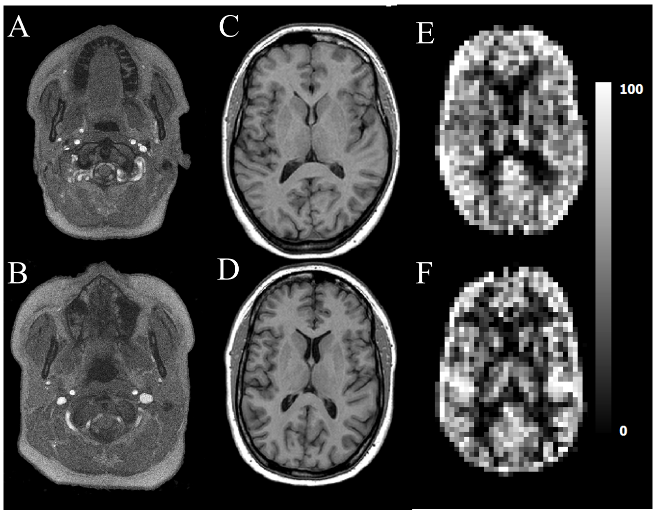

Figure 1: *Example of a 2D Qflow FFE magnitude (A, B), T1w anatomy (C, D) and corresponding ASL perfusion image (ml/min/100g), for a normal weight (top row) and obese volunteer (bottom row)*

Materials & Methods

19 healthy volunteers (8 obese (age 34.5±2.6, BMI 41.1±3.5) and 11 normal-weight (age 39.7±6.4, BMI 21.1±1.5)) were scanned on a Philips 1T open bore MRI system (Best, The Netherlands) using a 4-channel SENSE receive coil and body coil transmission. All volunteers were non-diabetic and had no symptoms of cardiovascular disease. The scanning protocol consisted of a 3D T1w FFE scan for anatomical reference and brain segmentation, followed by an ASL series for perfusion imaging (Multi-slice single-shot EPI pCASL with background suppression (BSup), 4x4x8 mm³ resolution, 80x44x14 matrix (AP/RL/FH), post-labeling delay=1300 ms, 8 min acquisition time, labeling duration=1300 ms, TE=7.1 ms, partial Fourier=0.7, TR=3316 ms, NSA=72, BSup=1600/2360 ms) and a 2D Qflow (at the pCASL labeling location) for labeling efficiency calculation (1 slice, 512x512 matrix, 0.45x0.45x4 mm³ resolution, Venc=80 cm/s). After acquisition, the ASL series was internally realigned and co-registered to the anatomical T1w FFE image with SPM8. Based on the 2D Qflow acquisition, the labeling efficiency was calculated in two different manners. With the first method, the labeling efficiency was *simulated* based on the velocity profile in the (carotid and vertebral) arteries [2]. Secondly, the labeling efficiency was *estimated* based on the total flow in the arteries [3]. The temporal SNR, total flow in the arteries, brain volume, labeling efficiency and mean Grey Matter (GM) CBF were subsequently calculated. Differences between the two volunteer groups were evaluated by means of an unpaired two-sided student t-test.

Table 1: *Summary of the calculated parameters, classified by weight group; p-values indicate significance level from the t-test*

	Normal *(mean±SD)*	Obese *(mean±SD)*	t-test (p-value)
tSNR	5.90±0.82	5.32±0.77	0.14
Total flow *(ml/min)*	642±87	599±67	0.26
Total brain volume *(cm³)*	1029±84	1080±88	0.23
Labeling efficiency (lab eff.)			
Model	0.85	0.85	N/A
Simulated	0.82±0.04	0.85±0.01	0.08
Estimated	0.83±0.11	0.77±0.11	0.37
Mean GM CBF *(ml/min/100g)*			
Model based lab eff.	41.3±6.8	35.1±4.5	**0.04**
Simulation based lab eff.	42.8±6.7	35.4±4.9	**0.02**
Estimation based lab eff.	42.6±5.7	38.6±3.9	0.10

Results

Figure 1.A.B show the 2D Qflow magnitude for a normal-weight (A) and obese (B) volunteer. A clear difference in neck volume can be seen between the normal-weight and the obese volunteer. The corresponding ASL perfusion (figure 1.E.F) and anatomical reference image (figure 1.C.D) are shown for the centre slice. The calculated temporal SNR, total flow in the arteries, brain volume, labeling efficiency (standard value used in model, simulated and estimated) and the corresponding mean Grey Matter CBF for both volunteer groups, are displayed in Table 1. With the exception of the mean GM CBF based on the modeled labeling efficiency and the mean GM CBF based on the simulated labeling efficiency, no significant differences between both groups were found for the different parameters. Remarkably, the difference in GM CBF between the groups disappears when using the estimated labeling efficiency as quantification parameter.

Discussion

We have illustrated that depending on the quantification method for the labeling efficiency, the statistical significance of perfusion differences between obese and normal weight volunteer groups can vary. One should therefore be careful in interpreting perfusion differences between obese and normal weight groups, especially with small sample sizes. This is even more crucial when applying ROI-analysis, since these perfusion variations are expected to increase with decreasing area of interest. Further research will include increasing the sample size and an evaluation of the effect of labeling efficiency variations on the results of a ROI analysis.

References

[1] van de Sande-Lee S, Pereira FRS, Cintra DE, et al. Partial Reversibility of Hypothalamic Dysfunction and Changes in Brain Activity After Body Mass Reduction in Obese Subjects. Diabetes 2011;60(6):1699-1704.
[2] Wu W-C, Fernández-Seara MA, Detre JA, Wehrli FW, Wang J. A theoretical and experimental investigation of the tagging efficiency of pseudocontinuous arterial spin labeling. Magnetic Resonance in Medicine 2007;58(5):1020-1027
[3] Aslan S, Xu F, Wang PL, et al. Estimation of labeling efficiency in pseudocontinuous arterial spin labeling. Magnetic Resonance in Medicine 2010;63(3):765-771.