Comparison of arterial blood volume obtained from model-free arterial spin labelling (ASL) and cerebral blood volume obtained from contrast enhanced dynamic susceptibility weighted imaging (DSC) in brain tumours

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Introduction

Cerebral blood volume (CBV) in brain tumours reflects vascularity and can be used to differentiate intracranial tumour types. Measurement of CBV with dynamic susceptibility weighted imaging (DSC-MRI) requires injection of a contrast agent. As an alternative, a recently introduced, model-free arterial spin labelling technique (ASL) named QUASAR enables quantification of cerebral blood flow (CBF) and arterial blood volume (aBV) [1]. In this study, aBV and CBF calculated from ASL and CBV and CBF obtained from DSC-MRI were determined in three types of brain tumours.

Subjects and Methods

Nine subjects with intracranial tumours (3 grade 2-3 gliomas, 3 glioblastomas and 4 meningiomas, two in one patient) were examined on a 3-T MR unit (Philips Achieva, Philips Medical Systems, Best, The Netherlands) with ASL (QUASAR) and DSC-MRI (GRE-EPI). ASL images were obtained with crushed arterial signal using a velocity-encoding gradient (crushed data) as well as with retained arterial signal (non-crushed data); two flip angles were used to obtain equilibrium magnetization in blood. QUASAR parameters were TR/TE/ΔTI/TI1=4000/23/300/40 ms, matrix=64×64, seven slices (6 mm thickness/2 mm slice gap), FOV=240 mm, flip angle=35/11.7°, SENSE factor 2.5, Venc=[∞ ,4 cm/s], and 82 averages (48 using Venc=4 cm/s, 24 using Venc=∞, 10 with smaller flip angle), implemented in a single sequence. For DSC-MRI, GRE-EPI was used with TR/TE=1360/29 ms, flip angle=90°, slice thickness=5 mm, 23 slices, FOV=220 mm, matrix=128×128 and SENSE factor 2.5. In both DSC-MRI and ASL, deconvolution was performed using a block-circulant singular value decomposition method [2]. In the ASL data, arterial signal curves were obtained by subtracting crushed from non-crushed data. aBV was obtained as the time integral of the arterial signal curve divided by the bolus area that corresponds to an initially labelled voxel with 100% blood volume. Under guidance of morphological information, ROIs of 0.08 cm^2 were placed in the lesion and in healthy grey matter (GM) (approximately 30 cm^2) and the ratio was calculated. Grey matter was used as a reference since the signal-to-noise ratio in white matter is low in ASL.

Results

Figure 1 shows maps of ASL-aBV, DSC-CBV, ASL-CBF and DSC-CBV in a meningioma. Mean results of the ratios from the four measurements and standard deviations are displayed in table 1. When assuming proportionality between aBV obtained from ASL and CBV obtained from DSC-MRI ratios the correlation was 0.89 (see figure 2). Comparing CBF ratios the correlation was 0.90 (see figure 2).

Figure 1
Gadolinium enhanced T1, CBF and CBV from DSC, CBF and aBV from ASL in a meningioma; ratios of lesion to GM for ASL-CBF and aBV were 7.0 and 2.6 respectively.

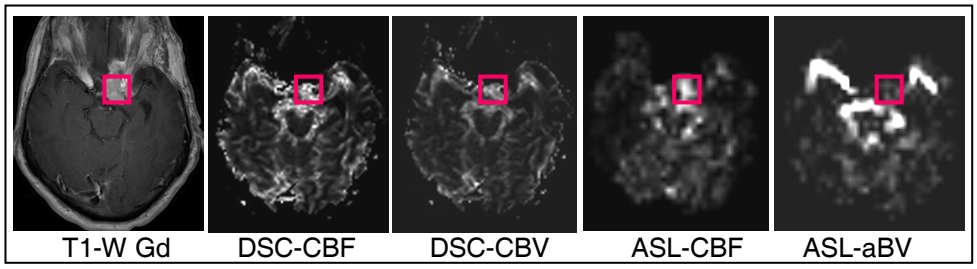
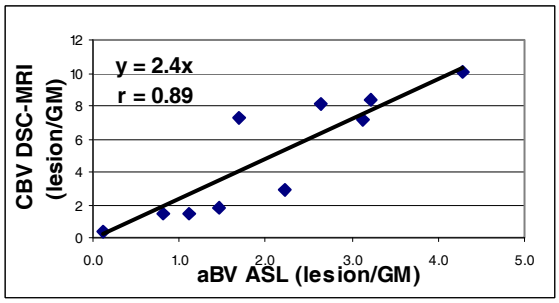
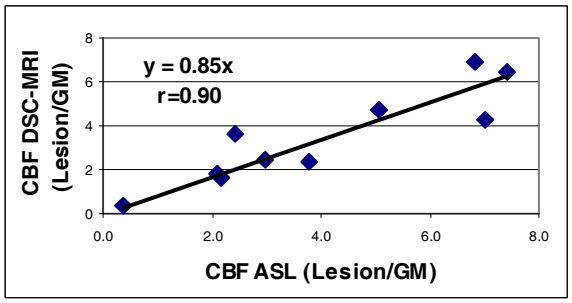


Table 1
Ratios of lesion to GM for the four parameters, mean and standard deviation

	ASL, aBV	DSC, CBV	ASL, CBF	DSC, CBF
Glioma gr 2-3	1.2±1.1	1.6±1.2	1.6±1.2	1.9±1.6
Glioblastoma	1.9±1.2	5.7±3.7	3.4±1.5	3.0±1.5
Meningiomas	2.9±1.2	6.8±3.5	6.2±1.7	5.0±2.1

Figure 2
Ratios of aBV/CBV (left) and CBF from ASL and DSC-MRI (right)





Conclusions

ASL-aBV correlated well to CBV determined with DSC-MRI (r=0.89) and likewise ASL-CBF and DSC-CBF correlated well (r=0.90).Our results also suggest a difference in aBV between tumour types (no statistic tests were performed as group sizes were small). As ASL is based on measurement of a diffusible tracer, it does not allow for determination of CBV. Instead, the blood volume in arteries and arterioles that has a velocity over a predefined threshold (4 cm/s in our case) is measured. This threshold is to be compared to the velocity in these vessels just proximal to the capillary bed that decreases from 10 cm/s to 0.2 cm/s suggesting that the arteries and most of the arterioles are included in measurement of aBV. Furthermore, in DSC-MRI a vascular artefact is often present that elevates CBV and CBF in the vessels and thus CBV obtained from DSC-MRI consists of aBV and venous blood volume from the large vessels and CBV from the tissue.
We conclude that aBV is a potential tool for characterisation of intracranial tumours, of special clinical interest as its measurement is non-invasive.

References

[1] Petersen ET et al. MRM. 2006;55:219-232. [2] Wu O et al. MRM. 2003;50:164-174.