Comparision of 3D pseudocontinuous arterial spin labeling (PC-ASL) with dynamic contrast enhanced (DCE) perfusion MRI

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Introduction

Gliomas are the most common cerebral neoplasms. These are being graded according to World Health Organization classification from grade 1 to grade 4. Grade 1& 2 are considered as low grade while 3 & 4 as high grade gliomas[1]. Grading of glioma is of utmost clinical importance as it determines the appropriate therapy to be used for patient's management. The current gold standard for glioma grading is the histopathological assessment of excised tumor. The stereotactic biopsy is limited by the inherent small sample size. Though Gadolinium based conventional MR imaging is routinely used to predict the grade of glioma, it often misleads the clinician[2]. Dynamic contrast enhanced (DCE) perfusion MRI has been widely used in assessment of glial neoplasm[3]. With availability of high field imaging, there has been a resurgence of arterial spin labeling (ASL) imaging that may be used as a non contrast brain perfusion method for quantification of CBF. In this study we prospectively compared DCE and 3D pseudocontinuous (PC) ASL MRI in glioma grading with histology as gold standard.

Materials and methods

***Subjects*:** Forty (27 male and 13 female; mean age=43 yrs) untreated consecutive patients (25 high grades & 15 low grades on histopathology) with definitive diagnosis of glioma were included in this study.

***Data acquisition*:** All patients underwent conventional, DCE and PC-ASL MRI on a 3.0T scanner (Signa HDxt, General Electric, Milwaukee, USA) using a 12 channel head coil. DCE-MRI was performed using a three dimensional spoiled gradient recalled echo (3D-SPGR) sequence [TR/TE/flip angle/ number of excitation(NEX)/slice thickness/ field of view (FOV)/matrix size=5.0ms/2.1ms/10º/0.7/6mm/240×240mm/128×128mm, number of phases=32]. At the fourth acquisition, Gd-DTPA-BMA (Omniscan, GE Healthcare, USA) was administered intravenously through a power injector at 5ml/sec, followed by 30ml saline flush. A series of 384 images in 32 time points for 12 slices were acquired (Temporal resolution: 6.03sec). Prior to 3D SPGR, two inversion recovery FSE (TR/TE/NEX/slice thickness/FOV/matrix size= 940ms/8ms/0.75/6mm/240×240mm/128×128mm) with inversion time 800 and 1600ms were performed for the same slice position to quantify voxel wise tissue T_{10}. The 3D PC-ASL was performed with Frequency/Phase/NEX/no. of slice/FOV/slice thickness/Band width/post label delay (PLD)=512/8/3/46/240mm/3 mm/62.50/1525ms.

***MRI data processing and quantitative analysis*:** Voxel wise tissue T_{10} was calculated from two inversion recovery sequences. Quantitative analysis of concentration time curve was performed for calculation of cerebral blood volume (CBV) and cerebral blood flow (CBF). Pharmacokinetic model was implemented for permeability (k^{trans} & k_{ep}) and leakage (v_e) calculation. Corrected CBV map was generated by removing the leakage effect of the disrupted BBB[4]. Both DCE dervived perfusion metrics and ASL derived CBF maps were fused and ROIs were drawn for quantification of perfusion metrics. Relative CBV (rCBV) and CBF (rCBF) were quantified by placing ROI on normal contra-lateral portion of the brain for DCE MRI. In addition, 3D PC-ASL was also performed on 20 healthy age/sex matched control subjects to look for the normal CBF values in grey and white matter regions.

***Statistical analysis*:** Student's independent t-test was used to look for the parameters with significantly different values in low and high grade tumors. A p-value ≤0.05 was considered as significant.

Results

All the DCE derived metrics except v_e (p=0.29) were found to be significantly higher in high grade as compared to low grade glioma (p<0.001) (table 1, fig 3), whereas ASL derived CBF did not show any significant differences (p=0.62) (fig. 1,2). The mean±sd values of CBF derived from 3D ASL imaging in grey and white matter regions of healthy normal control subjects were found to be 45.38±13.26 and 22.62±7.23ml/100gm/min respectively.

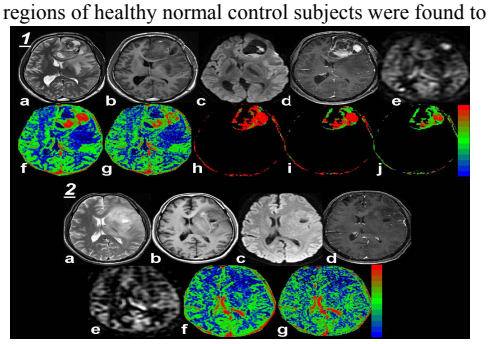

Fig:1)(a-d) conventional MRI of a high grade glioma (e) On ASL only a small region of the tumor is showing hyperperfusion, whereas on DCE derived (f)CBF (g)CBVcorr(h)k_{ep}(i)k^{trans}&(j)v_e high values in the cellular regions of the tumor is evident . 2))(a-d) conventional MRI of a low grade glioma (e) On ASL almost entire tumor is showing hyperperfusion, whereas on DCE derived (f)CBF & (g)CBVcorr maps do not show any significant increase in the tumoral tissue. Due to absence of blood brain barrier disruption, k_{ep}, k^{trans}, &)v_e did not show positive values (not shown)

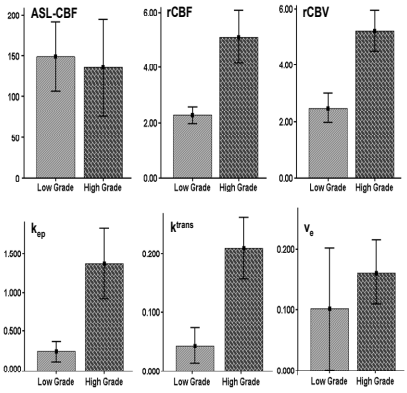

Fig 3: Bar diagrams showing values of perfusion metrices in low and high grade glioma. Error bar represent mean±0.5sd

Parameter	Mean ± SD		p-value
	Low Grade	High Grade	
ASL–CBF (ml/100g/min)	148.45±85.51	132.57±116.39	0.62
rCBF	2.28±0.62	5.13±1.91	<0.001
rCBV	2.49±1.04	5.23±1.48	<0.001
k^{trans} (Min^{-1})	0.04±0.05	0.21±0.10	<0.001
k_{ep} (Min^{-1})	0.25±0.27	1.40±0.92	<0.001
v_e	0.10±0.20	0.16±0.10	0.29

***Table.1:** Mean and standard deviation values of ASL and DCE derived perfusion metrics*

Discussion

With increased availability of high field imaging and refinement in technology, attempts to develop roburst non-contrast perfusion MRI using ASL technique have been made widely as it is known to provide absolute quantification of CBF. It is totally non-invasive technique to study perfusion even in patients with renal failure and can be performed repeatedly. However, despite of considerable improvement inmethodology, it may not always prove to be consistent due to possible inter-subject variability as a result of various physiological conditions which may affect the quantification. In this study, DCE-MRI proved to be superior in differentiating high grade from low grade glioma as compared to 3D PC-ASL technique. We conclude that ASL technique still requires improvement to overcome the variability in its quantification to become a reliable tool in clinical decision making of cerebral glioma grading. On the other hand DCE-MRI provides pharmacokinetic (k^{trans} and k_{ep}) as well as hemodynamic parameters (CBV and CBF), which helps to characterize tumor physiology in a more comprehensive manner by providing information about the degree of blood brain barrier disruption as well as neoangiogenesis.

References

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