Simultaneous Measurement of DSC- and DCE-MRI Parameters using Dual-Echo Spiral with a Standard Dose of Gadolinium in Comparison to Single-Echo GRE-EPI Methods in Brain Tumors

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Target Audience: Neuro-oncologists, neuroradiologists, neurosurgeons, brain tumor imaging scientists.

Purpose: In a previous study comparing an array of methods to collect and analyze DSC-MRI data, the dual-echo gradient-echo spiral-based (DEGES) method proved to be one of the most accurate for the creation of relative cerebral blood volume (rCBV) maps in brain tumors[1]. The DEGES method has the added advantage of being able to simultaneously collect both DSC and DCE (dynamic contrast enhanced) data, all with just a single dose of gadolinium (Gd) contrast agent. Though promising, a full evaluation of this DEGES method by comparison to standard GRE-EPI DSC methods, which use a pre-load dose of Gd to improve accuracy, has not been previously undertaken, and is therefore the goal of this study. In addition, the feasibility of collecting meaningful DCE data is addressed.

Methods: ***Patients*:** A prospective study was performed on a cohort of patients with primary glial neoplasms. We collected 29 stereotactic tumor biopsies (from 7 patients), co-registering the biopsy locations with pre-operative MRI, which included conventional MRI, DEGES (TE1/TE2=3.3ms/4.2ms;TR=1500ms;FA=60), and GRE-EPI based DSC-MRI (TR/TE=1500/20ms;FA=60). All studies were performed on a 3T MR scanner (GE Healthcare, Milwaukee, Wisconsin). ***Acquisition:*** The DEGES perfusion MRI was acquired before, during, and after an initial iv bolus injection of Gd contrast (Multihance; 0.1 mmol/kg dose). Subsequently, a second injection was employed for GRE-EPI DSC acquisition. The first injection from the DEGES acquisition served as the preload dose for the GRE-EPI acquisition. Post-contrast anatomical SPGR stereotactic MRI was also performed to enable coregistration of the datasets with neuro-navigationally documented biopsy locations. ***Processing:*** For DCE analysis, the DEGES signal time courses obtained at TE1 were used to determine the $\Delta R1(t)$ concentration-time curves. The DCE parameters Ktrans, Kep, Vp and Ve were estimated on a voxelwise basis by non-linear least squares fitting using the extended Tofts model[2]. For DEGES rCBV analysis, R2*(t) concentration-times were constructed and a model that accounts for the first pass and residual susceptibility or dipolar T2 leakage effects applied[3,4]. Finally, estimates of rCBV were generated from the GRE-EPI data using IB Neuro™ (Imaging Biometrics LLC), which incorporates correction for contrast agent extravasation[5]. For each method both normalized and standardized rCBV maps (nRCBV, sRCBV) were determined, where a reference ROI in normal appearing white matter was used for nRCBV and a standardized transformation, which precludes the need for drawing a reference ROI, was used to generate sRCBV[6]. Only standardized maps, which demonstrated greater consistency, are reported here.

Results: The pathologic diagnosis included ten low-grade (LG) samples, comprised of astrocytoma grade II and pilocytic/glioneuronal tumor tissue. The 19 remaining high-grade (HG) samples consisted of grade III astrocytoma, grade III oligoastrocytoma and glioblastoma. Shown in Figure 1 are example DCE (Ktrans), DEGE sRCBV and GRE sRCBV maps from a patient with a GBM. Statistically significant differences were found between LG and HG tumors for Ktrans (p=0.005) and sRCBV for both DEGES (p=0.027) and GE-EPI (p=0.048) using an unpaired t-test (Fig 2). No statistical differences were found for sRCBV between methods (Fig 3).

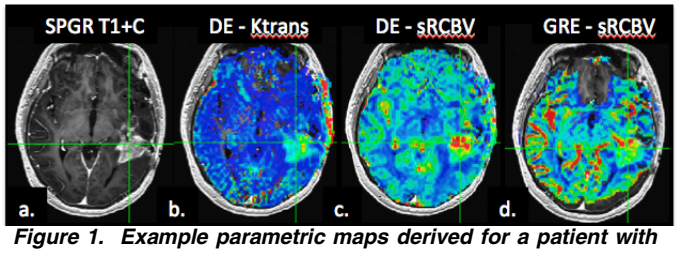

***Figure 1. Example parametric maps derived for a patient with GBM**. The DCE and DSC parameter maps, Ktran (b) and sRCBV (c)were both derived from the DEGES method. The sRCBV map determined from the GRE-EPI method is also shown for comparison.*

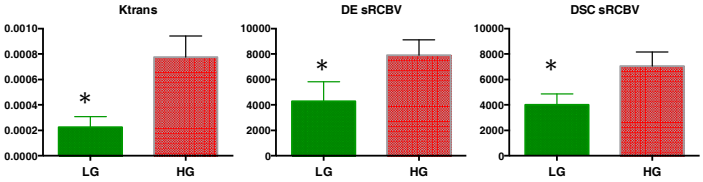

***Figure 2. DEGES and GRE-EPI parameters** are able to distinguish between LG and HG brain tumors.*

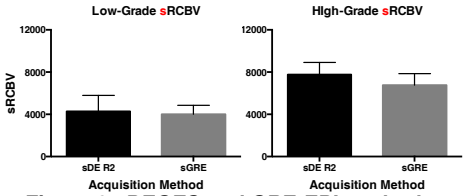

***Figure 3. DEGES and GRE-EPI methods** give comparable sRCBV results.*

Discussion: These results demonstrate that the single dose DEGES method gives results comparable to the more proven pre-load/GRE-EPI based DSC-MRI methods for the evaluation of brain tumors and in particular the distinction between grades. In addition, DEGES has the added advantage of simultaneously providing DCE data using only a single dose of Gd contrast agent.

Conclusion: Dual-echo spiral-based DSC-MRI methods, which require only a single dose of Gd contrast, hold promise for providing a multiparametric array of perfusion parameters relevant to the evaluation of brain tumors. These initial results, which demonstrate an equivalence to proven methods, suggest that DEGES may quickly become the perfusion method of choice.

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