Diagnostic Performance of Dynamic Susceptibility Contrast Perfusion in Glioma Grading: Comparison of Cerebral Blood Volume among Different Analysis Software

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Target Audience: Neuroradiologists and other researchers who are interested in dynamic susceptibility contrast (DSC) perfusion for cerebral gliomas.

Purpose: Dynamic susceptibility contrast (DSC) perfusion imaging is widely used for brain tumors, such as grading of primary glioma, differentiation of tumor types, and discrimination of tumor recurrence from radiation necrosis. Cerebral blood volume (CBV) has been commonly used for glioma grading, as CBV reflects micro-vascularity. Recently, a variety of post-processing programs and algorithms for DSC have been made available by MR manufacturers, third-party workstation vendors, and academic groups. However, there are substantial differences between these programs and algorithms in terms of their maps and quantitative values in DSC as well as CT perfusion. These difference in calculation method potentially affects diagnostic performance in the variety of clinical applications; however, there has been few reports which investigated software difference in tumor imaging. The purpose of the present study was to compare rCBV value of DSC perfusion and diagnostic performance of rCBV for discriminating low grade and high grade tumor among different software packages in patients with cerebral glioma.

Methods: Thirty five patients with primary glioma (grade II, 9; grade III, 8; and grade IV, 18 patients, respectively) were included. DSC perfusion was performed with 3-Tesla MRI using gradient echo (GRE) echo planar imaging (EPI) and rapid injection of Gd contrast. The scan parameters included TR of 1400 ms, TE of 32 ms, FOV of 230 mm, imaging matrix of 128×128, slice thickness of 5 mm, 19 sections, and 50 phases. CBV maps were generated by 11 different algorithms of four commercially available software (GE Healthcare, Philips Medical Systems, Siemens Healthcare, and Infocom) and one academic program (Perfusion Mismatch Analyzer [PMA]). Among them, the area under the curve (AUC) method was used for CBV calculation in six algorithms, and deconvolution with AIF was used in five algorithms. All five deconvolution algorithms used singular value decomposition (SVD). rCBV of each tumor compared to normal white matter was calculated by region-of-interest (ROI) measurements. Five ROIs (diameter of 2 mm) were manually placed in the high CBV area of tumor on each CBV map, repeated for two to five sections. Ten ROIs of the same diameter were also placed in the contralateral normal white matter. Then, relative CBV (rCBV) value of each tumor was calculated. Differences in rCBV value among algorithms were compared for each tumor grade. Differences in rCBV value among glioma grade were also compared for each algorithm. These comparison was performed with multiple comparison test of Steel-Dwass. Receiver operator characteristics (ROC) analysis was conducted for the evaluation of diagnostic performance of rCBV for differentiation among different grades.

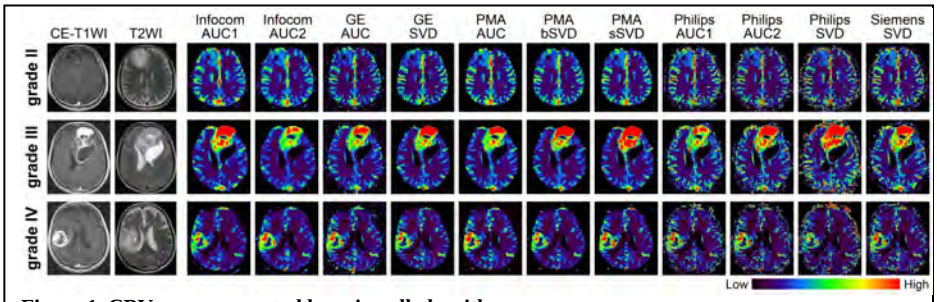

Figure 1. CBV maps generated by using all algorithms.
Representative cases with grade II, III, and IV tumors are shown. All the CBV maps are displayed with the identical color bar. Grade III and IV tumors have higher CBV than grade II tumor in all the algorithms. Visually, these maps seem to be similar; however, the degree of CBV increase and the amount of image noise are variable among software and algorithms.

Results: All the CBV maps looked similar; however, conspicuity of large vessels and image noise were different among algorithms (Figure 1). rCBV increased with the increase of tumor grade in all algorithms (Figure 2). Significant differences were noted between grade III and IV and between low grade (II) and high grade (III and IV) in all the algorithms, while there were no significant differences between grade II and III. In comparison among software, there are a lot of pairs which have significant difference in rCBV, especially for grade IV tumors. In the differentiation between low grade (II) and high grade (III/IV) tumors, the area under the curve (Az) of ROC were similar (ranged from 0.85 to 0.87), and there were no statistical difference in Az between any pair of algorithms. In contrast, optimal cut off values varied among algorithms (ranged from 4.18 to 6.53).

Discussion: In this study, we have demonstrated that rCBV values were different among software in patients with intracranial gliomas. Values of rCBV was calculated as the relative value to contralateral normal white matter; therefore, the values are normalized within a subject. But still the values were different, even with the same software as well as the same kinds of algorithms (such as AUC or SVD) of different software, which means that detailed implementation of analysis might be different.

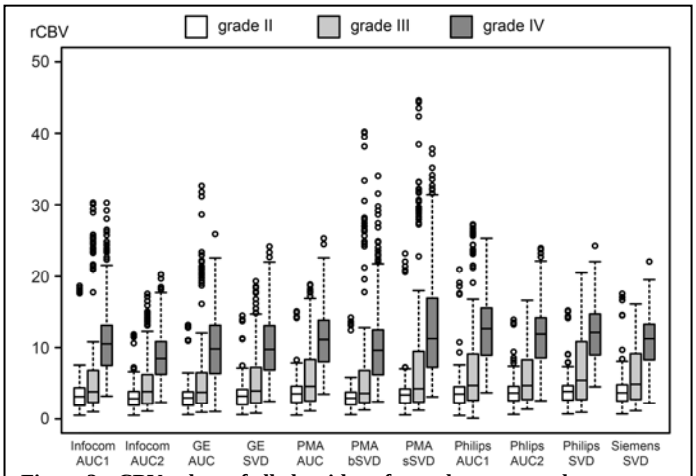

Figure 2. rCBV values of all algorithms for each tumor grades.
Relative CBV (rCBV) increases with the increase of tumor grade in all algorithms. Significant differences were noted between grade III and IV and between low grade (II) and high grade (III and IV) in all the algorithms, and there were no significant differences between grade II and III.

Compared to grade II and III, grade IV tumors had more variations in rCBV, the values of which were higher than grade II and III. Conspicuity of large vessels and image noise were different among algorithms on visual assessment; therefore, the source of difference might due to the difference in CBV value in highly perfused area. However, the actual implementation of each perfusion analysis is unknown especially for commercial software. Even though rCBV values were different, ROC analysis revealed that the diagnostic performances (Az values) for tumor grading were not significantly different among software, although some differences were noted in discriminating grade III and IV. However, cut off values for the discrimination of different grades were variable for different software packages, probably because of the differences in rCBV values. Therefore, optimal cut off values should be used for each software. Care should be taken if the previous report showed a cut off value, it cannot be applied in your institute, because the different software might be used for the analysis.

Conclusion: Diagnostic performances of rCBV for glioma grading were not statistically significant among post-processing software. However, rCBV values and cut off values for discriminating low grade and high grade gliomas were different among algorithms.

References:

1. Arvinda HR, et al. J Neurooncol. 2009;94(1):87-96.
2. Lev MH, et al. AJNR Am J Neuroradiol. 2004;25(2):214-21.
3. Kudo K, et al. Radiology. 2009;251(1):241-9.
4. Kudo K, et al. Radiology. 2010;254(1):200-9.
5. Christensen S, et al. Stroke. 2009;40(6):2055-61.