Quantitative Evaluation of Apparent Diffusion Coefficient Values and Permeability Parameters from Dynamic Contrast-enhanced MR in Both Tumor Parenchyma and Peritumoral Area for Distinction of Brain Tumors

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Aims and objectives

Preoperative accurate brain tumor diagnosis plays an essential role in the selection of the optimum treatment strategy, as their management and prognosis are different. However, conventional structural imaging for accurate tumor diagnosis and grading is still challenging. Advanced MR imaging techniques, such as perfusion (dynamic contrast enhanced MRI [DCE-MR]), diffusion weighted imaging (DWI) and MR spectroscopy, can provide much important information on physiology and metabolism in vivo, that could be aid in gliomas grading, tumor margin defenition and differential diagnosis of brain tumors [1-7].

In addition, most of the previous investigators were interested in the tumor parenchyma (TP) but not the peritumoral (PT) area. Nearly all brain tumors are accompanied with the PT area abnormality. From a pathological point of view, PT area signal abnormality represents a tumor induced increase in interstitial water. Whereas, in high-grade gliomas (HGG) and primary central nervous system lymphoma (PCNSL), the PT area signal abnormality is not only caused by the altered interstitial water but also by the infiltration of the scattered tumor cells [8,9]. Thus, inspecting the PT area with different brain tumor types could help our diagnosis.

Therefore, the purpose of our study was to quantitatively evaluate the diagnostic efficacy of ADC and permeability parameters based on tumor parenchyma (TP) and peritumoral (PT) area in classification of brain tumors.

Methods and materials

In accordance with ethical guidelines for human research, and in compliance with the Health Insurance Portability and Accountability Act (HIPAA). This study was approved by our institution. Written informed consent was obtained from each adult patient or their legal guardian.

Fourty-five patients (male: 23, female: 22; mean age: 46 y) were prospectively recruited in our study. They underwent conventional, DCE-MR and DWI examination. With each tumor, ROI analysis was according to the recommendation of early studies [10-12]. ROI was placed after consensus of two experienced radiologists, 10-15 regions of interest (ROIs) were manually placed on TP and PT area (within a 1cm distance from the outer enhancing tumor margin) area Fig. 1 on page 3. ADC values were measured from ADC map, and permeability parameters (Volume transfer constant ($K_{\text{trans}}$), extra-vascular extra-cellular volume fraction (Ve), reflux constant (Kep) and iAUC (initial Area Under
Curve in 60 seconds) were calculated by a commercial software tool (TISSUE 4D; Siemens Healthcare, Erlangen, Germany) and their diagnostic efficiency were assessed.

Statistical analysis was carried out using the software (SPSS 16.0 Chicago, Illinois). The association of the different quantitative permeability parameters and ADC value with tumor classification and gliomas grading was evaluated by analysis of Kruskal-Wallis. The relationship between different types of CTVs and tumor classification was evaluated by chi-square test. Receiver operating characteristic (ROC) analysis was performed for glioma grading. Nonparametric estimates and 95% CIs for the area under the ROC curves (AUCs) were calculated. Optimal thresholds for gliomas grading were determined. Sensitivity, specificity, and the 95% CIs were calculated. P<0.05 was considered statistically significant.

**Images for this section:**

![Fig. 1: Fig.1 A example of ROIs placing. A 67 years old man with a suspicious high grade glioma in right temporal lobe on T1-weighted contrast-enhanced MRI. ROI 2 and ROI](image-url)
3 were placed in the tumor parenchyma and peritumoral area, respectively; ROI 4 was putted in the contralateral normal hemisphere
Results

In TP, all permeability parameters and ADC value could significantly discriminate High-from Low grade gliomas (LGG) (p<0.001); among these parameters, Ve demonstrated the highest diagnostic power (iAUC: 0.79, cut-point: 0.15); the most sensitive and specific index for gliomas grading were $K_{\text{trans}}$ (84%) and Kep (89%). While, in PT area, only $K_{\text{trans}}$ could help in gliomas grading (P=0.009, cut-point: 0.03 min$^{-1}$) Fig. 2 on page 5, Fig. 3 on page 6. Moreover, in TP, mean Ve and iAUC of lymphoma or metastases were significantly higher than that in HGG (p<0.003). Further, in PT area, mean $K_{\text{trans}}$ (p<0.004) and ADC (p<0.003) could separately discriminate lymphoma and metastases from HGG.

Images for this section:

Fig. 2: Fig.2 A 24 years-old male with low grade gliomas (WHO#) near the fourth ventricle (a, b, c) and a 59 years-old male with high grade gliomas (WHO #) in the left cerebellar hemisphere(d, e, f). Permeability parameter (Ktrans) maps of the two tumors
Concentration-time curve (CTV) of each tumor: the CTV of the low grade glioma manifested as plateau (b), the other one showed as a slowly rising curve(e); specific histologic type of each tumor: pilocytic astrocytoma (c) (Hematoxylin- Eosin(HE) ×4), small cell glioblastoma (f), (HE ×10)

Fig. 3: Receiver operating characteristic (ROC) curves and area under the curve (AUC) values for significant permeability parameters and ADC in tumor parenchyma (Left) and peritumoral region (Right). In tumor parenchyma, Ve is the most powerful parameter to differentiate low- from high grade glioma(HGG), while in peritumoral area, only Ktrans showed significant difference in low- and HGG.
Conclusion

Evaluating both TP and PT area of brain tumor could give more information for differential diagnosis; ADC, kep, Ve and iAUC in TP and $K^{\text{trans}}$ in both area were useful in gliomas grading; Ve and iAUC in TP could differentiate lymphoma or metastasis with HGG, while, in PT, $K^{\text{trans}}$ could help in discriminating HGG from lymphoma.

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References


