Model Independent Method on Modified DCE-MRI Perfusion Data for Exploring Area and Grade of Gliomas

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Introduction: A common approach to diagnose and characterize a brain tumor by using DCE-MRI perfusion data is to generate maps of volume transfer constant (K^{trans}) and fractional extracellular-extravascular space volume (V_e) from pharmacokinetic models [1-2].   There is no universally accepted model and the ability of the models to discern Grade III from Grade IV gliomas [3-4] is not optimal. In this study, we sought to apply a model independent method, i.e., Probabilistic Independent Component Analysis (PICA), on modified DCE data for finding a tumor area and distinguishing its grade.

Materials and Methods: Retrospective analyses of the DCE-MRI data of 28 patients (ten females, eighteen males; age: 47.11±14.18 years) with histologically confirmed I-IV grades of gliomas (8 grade I, 6 grade II, 6 grade III, and 8 grade IV) were performed by applying the PICA [3-4] method for this study. The 28 data sets were acquired using the same protocal in a previous report [2]. The data processing steps prior to the PICA included the motion correction, the spatial smooth with a 5mm Gaussian kernal and the baseline modification which was done by divideding each intensity value to the avarage intensity value in the selectd time range. Skull areas were also removed from the DCE data for having a better and quick PICA. The Melodic modual in FSL [5], which performs the PICA, was applied to find the tumors' spatial maps and associated intensity-time curves. From the curves, we extracted several parameters (see the Table 1), including the wash-in slope. A Mann-Whitney U-test was applied to compare the low (II) with high (III and IV) grades, the grade II with III, the grade II with IV, and III with IV. A P less than 0.05 was regarded as statistically significant.

Results and Discussions: The PICA on the modified DCE data determined all the gliomas' areas except all the grade I. One example was displayed in the Fig 1 in which a white arrow pointed to the grade III gliomas. The corresponding red area in the right image of the Fig 1 and the associated time-intensity curve (i.e., the tumor component's curve) were determined by the PICA. The avarage normalized DCE time-intensity curves for the tumor areas of each grade were ploted in Fig 2 for with (the left) and without (the right) the baseline modification. The P values between two grade groups for the slopts, the time to peak, the peak height and the area under the curves were calculated based on the tumor component's curves of the tumors with the baseline modification and lised in the Table 1. The P values suggested that the slopes of "the tumor DCE curves" based on the PICA on the modified baselines is the best parameter for distingushing the tumor grades since it can be applied to distingush all II-IV grades and the low from the high grades. The P values for the DCE curves without the baseline modification suggested these four parameters in the Table 1 can not be applied for grading the tumors.
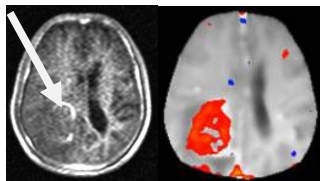
Figs 1

Fig 2

Fig.1 The T1 image (the left, the tumor was point by the white arrow) and the tumor component (the corresponding red area) determined from the PICA (the right) of a patient with an III grade.
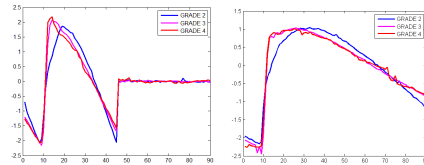

Fig.2 Average normalized DCE time-intensity curves for the grades (II-IV) with (the left) and without (the right) the baseline modification on the curves.

Table 1: P values of parameters form comparing them in two tumor grade groups.

	Slope	Time to peak	Peak height	Area under curve
2 vs 4	0.0002	0.0009	0.0074	0.6281
2 vs 3	0.0129	0.0099	0.0384	0.6345
3 vs 4	0.0092	0.2417	0.1071	0.6705
2 vs (3 & 4)	0.001	0.0001	0.016	0.4763

Conclusion: The PICA on the "baseline modified" DCE time-intensity cuvers accuratly determined the tumor areas for the grade II to IV, and the slopes of associated the time-intensity curves (i.e., the tumor component's curves) of the tumor areas which were determined from the PICA can distingush the low grade (II) from high grade (III and IV) , II from III, II from IV, and III from IV.

References: [1] Jain R, et al., AJNR Am J Neuroradiol 2008; 694-700. [2] Hou, BL, et al., 19th ISMRM Conference, Montreal, 2011. [3] Tofts PS, et al., J Magn Reson Imaging 1999; 223-232. [4] Na Zhang, Bob Hou,et al., JMRI, 2012 ; 355-363 [5] Smith, SM., et. al., NeuroImage, 2004; 208-219.