Phase-derived vascular input functions for 2D DCE-MRI of cerebral gliomas: reproducibility and diagnostic value

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Introduction: Quantitative dynamic contrast-enhanced (DCE) MRI provides maps of tracer kinetic parameters (TKPs) which can be useful for predicting tumor aggressiveness. TKP reliability increases with DCE-MRI temporal resolution. One strategy for increasing temporal resolution is to use 2D sequences with limited coverage. However, this results in distortion of the measured vascular input function (VIF) due to signal saturation at high Gd concentrations and severe inflow effects (1-3). A relatively new way to solve this problem is to use a phase (ϕ)-derived VIF (VIFϕ), which does not saturate and is less vulnerable to inflow (1-2). Since with any new technique there is the possibility that it may introduce new inaccuracies, one must ask whether TKPs calculated with a patient-specific VIFϕ are at least as reproducible and diagnostically valuable as TKPs calculated using an accepted standard VIF, which in this case was a population-averaged VIF (VIFpop) (4).

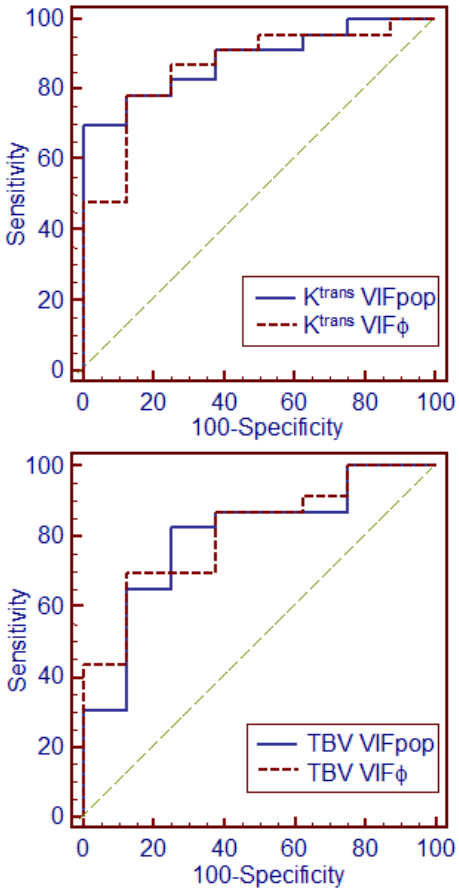
Purpose: To compare the reproducibility and diagnostic value of TKPs calculated with VIFϕ and VIFpop for a cohort of cerebral glioma patients. We hypothesized that VIFϕ would perform at least as well as VIFpop.

Methods: 31 patients with cerebral gliomas were studied [8 low-grade (II), 23 high-grade (III-IV)] at 1.5T. For DCE, magnitude and phase data were saved from 2D FLASH: TR=46 ms, TE=2.06 & 5.48 ms, α=90°, Δz=5.5 mm, gap=2.75 mm, 1 axial slice through the neck and 4 axial slices through the tumor and superior sagittal sinus (SSS), Δt=2.2 s, total time=3.6 min, Gd dose=0.1 mmol/kg. T_1 measurements were performed on the tumor before & after DCE using the variable flip angle method (TR/TE=50/2.16, flip angles=10,20,40,70°) (5). VIFϕ was measured in the SSS, accounting for vessel angle effects (1). In tumor, the concentration-vs-time curve was calculated using the "Bookend Method"; in neck muscle it was calculated assuming T1 pre-Gd=1 s (6). K^{trans}, tumor blood volume (TBV) and distribution volume (ve) maps (7-9) were calculated using VIFϕ and a published VIFpop (4). ROC analyses were performed for TKP prediction of tumor grade (low vs high) and comparison of AUCs using the Z-statistic. 11 patients underwent a second followup study post-surgery. Reproducibility of TKP measurements in the neck muscle of these 11 patients was evaluated using the coefficient of variation and the intraclass correlation coefficient.

Results: VIFϕ was superior to VIFpop for TKP reproducibility (Table 1). VIFϕ- and VIFpop- derived TKPs provided equal diagnostic value (p>0.6) (Fig 1).

	K^{trans}		v_e	
	VIFpop	VIFϕ	VIFpop	VIFϕ
Overall mean	0.036	0.038	11.6	14.4
Overall std.dev.	0.023	0.019	7.8	8.5
Coeff. of Variat. (%)	**62.7**	**49.0**	**67.0**	**59.2**
Intraclass Correl. Coeff.	**-0.07**	**0.38**	**-0.22**	**0.36**
ICC lower 95% conf.	-0.62	-0.25	-0.70	-0.27
ICC upper 95% conf.	0.53	0.78	0.41	0.78

Table 1 (above): Reproducibility of VIFϕ versus VIFpop for TKP in neck muscle.
Figure 1 (right): ROC K^{trans} (top) and TBV (bottom) (prediction of tumor grade).



Conclusion: For DCE-MRI of cerebral gliomas employing 2D sequences and limited coverage, the use of phase-derived vascular input functions improves TKP reproducibility and does not adversely affect tumor grading.

References: 1. Foottit, MRM 2010;63:772. 2. Cron, MRM 2011;66 :498. 3. Peeters, MRM 2004; 51: 710. 4. Parker, MRM 2006;56: 993. 5. Fram, MRI 1987; 5: 201. 6. Cron, MRM 1999; 42: 746. 7. Ott, Eur J Cancer 1991; 27: 1356. 8. Tofts, JMRI 1997; 7: 91. 9. Tofts, JMRI 1999;10:223.