Quantitative MR Perfusion and Ischemic Stroke: Improved Discrimination between Ischemic and Presumed Penumbra Using qCBF over Tmax or MTT

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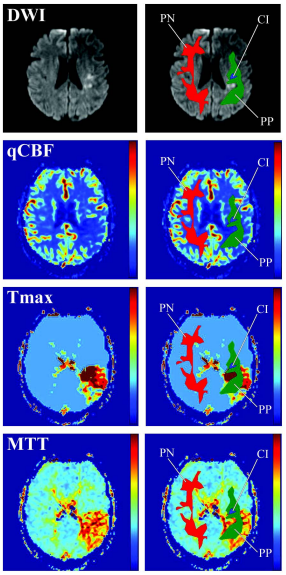
Introduction:

Ischemic stroke leads to significant morbidity, mortality and health care expeditures in the United States. Stroke severity and potential efficacy of reperfusion therapy can be predicted by the degree of cerebral blood flow changes (CBFΔs). Time-based indicators of CBFΔs, e.g., time to peak (Tmax) and mean transit time (MTT), tend to *overestimate* the infarcted region, thus underestimating potentially salvageable brain by reperfusion therapy. Improved quantification of CBF with quantitative MR perfusion (qMRP) can be accomplished using the "Bookend" technique by using post-Gd T1 changes. We hypothesized and that qMRP and qCBF are more accurate at distinguishing normally perfused from critically ischemic brain than relative and time-based measures, e.g., Tmax or MTT, thus providing more accurate ischemic thresholds for therapy.



Methods:

In 9 stroke patients, the mean values of qCBF, Tmax, and MTT using a 1.5T MR scanner (Avanto, Siemans AG Healthcare Sector, Erlangen, Germany) with GRE-EPI perfusion sequences. Images were acquired using a single-dose injections of Gd-DTPA (0.1 mmol/kg b.w.), each time at a rate of 4ml/s. Regions of interest (ROIs), were drawn on diffusion weighted images in 3 areas: 1) diffusion positive, critically ischemic (CI), 2) ipsilateral normal region immediately surrounding the critically ischemic region, the presumed penumbra (PP), and 3) contralateral diffusion negative control, presumed normal region (PN) of gray and white matter separately (GM and WM) (Figure 1).

Results:

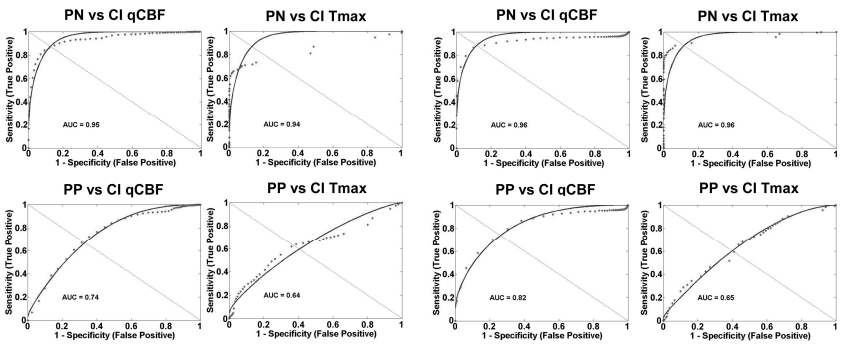
In both GM and WM, qCBF measures distinguished the ROIs with the most markedly reduced values in regions corresponding to the extent of ischemic injury. In planned comparisons, only qCBF measurements differed significantly between CI and PP tissues. Receiver Operator Characteristic analysis demonstrated the utility of qCBF for discriminating brain regions differing in the extent of ischemic injury (CI and PN regions – qCBF: AUC=0.96, Tmax: AUC=0.96, MTT: AUC=0.72). Importantly, qCBF provided the best and most accurate discrimination of CI and PP regions (qCBF: AUC=0.82, Tmax: AUC=0.65, MTT: AUC=0.52).

	qCBF WM (ml/100g-min)	qCBF GM (ml/100g-min)	Tmax WM (s)	Tmax GM (s)	MTT WM (s)	MTT GM (s)
Normal	21.55±4.19	48.9±6.24	3.47±0.98	2.37±0.39	4.80±1.07	3.70±1.16
Infarct	8.07±2.93	12.05±5.64	9.12±3.08	6.20±2.19	5.36±3.94	6.23±1.37
Halo	14.22±1.43	28.68±10.77	7.86±1.65	5.84±1.81	5.39±1.86	5.69±0.87

Conclusions:

We show that quantitative MR perfusion and qCBF improved the discrimination between CI and PP compared to time-based imaging metrics. These determinations would allow a more accurate determination of extent and benefit of reperfusion therapy in vascular disease and ischemic stroke patients.

Keywords: MR quantification, cerebral blood flow, ischemic stroke



WM ROC Plots GM ROC Plots

References:

Williams et al. Stroke 1999; Shin et al. MRM 2007; Olsen et al. Stroke 1983