Quantitative Permeability MRI in Acute Ischemic Stroke: How Long Do We Need to Scan?

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Introduction:

Dynamic T1-weighted MR permeability imaging with subsequent pharmacokinetic modeling, provides valuable information on blood-brain-barrier (BBB) integrity in acute ischemic stroke (AIS) and can lend insight into which AIS patients later develop hemmorrhage (1). However, the relatively long scan duration is problematic in critically ill AIS patients. In this work we examine the effects of reducing scan time on quantitative permeability (KPS).

Methods:

Permeability data from 8 AIS cases were retrospectively analyzed. Of the 8 patients scanned, 3 subjects developed hemorrhage. All scanning was done on a 1.5T GE Signal LX 12.0 MRI system equipped with Echo-Speed gradients and an 8 channel head coil. Permeability MRI was performed as part of the acute stroke protocol (3D GRE, FOV = 240mm, matrix 256x192, slice thickness 7mm, TR/TE = 5.9/1.5 ms, FA 20°. Total acquisition time for 31 volumes was 4:48 minutes. Data was analyzed offline using custom-developed software in Matlab. Two regions of interest (ROI) were defined on the DWI images – with one being placed on the core region of the diffusion abnormality and the second one being placed in the contralateral hemisphere. These ROIs were then copied to the corresponding permeability images. Quantitative permeability (KPS) was calculated as previously described by Roberts et.al (2) who used a linear-least-squares estimator to compute the KPS value. Based on linear algebra techniques, namely the singular value decomposition (SVD), the standard deviation of the resulting KPS estimates were computed as a function of scan time (3). Plots for scan times of 2 min 30 s, 3 min 30 s or all 4 min 48 s were generated. Average KPS values for all patients were then computed.

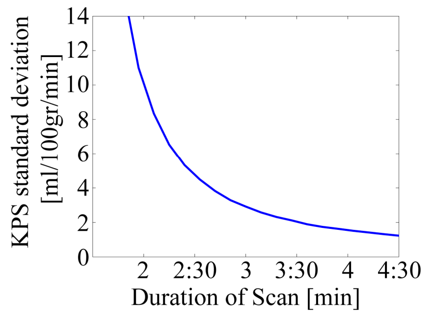

Figure 1: As scan time is reduced the KPS estimate becomes more and more uncertain.

Results:

Figure 1 shows the standard deviations of the KPS estimates as more and more data is used for analysis. The uncertainty in the resulting KPS estimate increases dramatically as less data is used. Illustrated in Fig. 2 are the resulting KPS estimates when 2 min 30 s, 3 min 30 s and all 4 min 48 s of data were used. A statistically significant difference (P-value < 0.05) between those who developed hemorrhage and those who did not was found when 3 min 30 s and all 4 min 48 s min of data were used.

Discussion:

The results indicate that the uncertainty in the KPS estimates increases as less and less data is available for analysis. The data indicate that reliable results can be obtained with as little as 3 min and 30 s of scanning using this protocol. This scan time is still considerably longer than the scan time achievable with routinely used T2* weighted perfusion sequences (4). Future work will determine if further scan time reductions can be achieved by combining the two methods.

References: (1) Kassner et al. AJNR 2005, (2) Roberts et al. AJNR 2000, (3) Boyd et al. Cambridge Press (2004), (4) Flacke et al. JMRI 2000

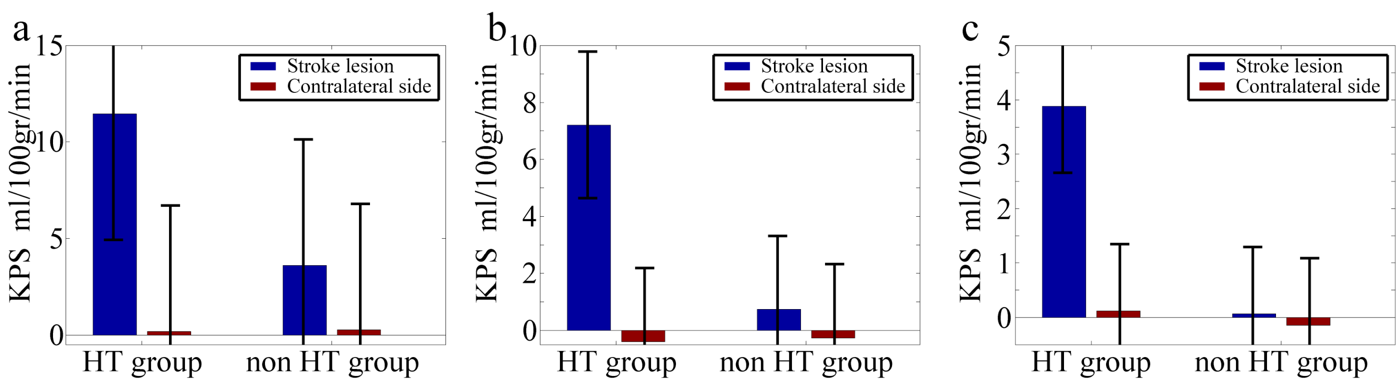

Figure 2: KPS estimates for the two groups when (a) 2 min 30 s, (b) 3 min 30 s and (c) all 4 min 48 s of data are used. As shown in Fig. 1 the standard deviations increase dramatically as less and less data is available for analysis. If 3 min 30 s or 4 min 48 s of data are used, there is a significant (P-value < 0.05) difference between the two groups, however if only 2 min 30 s of data is used, the difference is not significant (P-value > 0.1).