Assessment of Blood-Brain Barrier Injury Following Acute Intracerebral Hemorrhage by DCE MRI

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Introduction: Blood-brain barrier (BBB) disruption as well as perihematomal injury and edema are commonly observed as a result of spontaneous intracerebral hemorrhage (ICH). BBB injury is potentially an important pathophysiological factor in secondary brain injury caused by ICH [1]. The aim of this study was to detect changes in BBB permeability and quantify BBB injury following acute ICH by using dynamic contrast-enhanced (DCE) MRI.

Material and Methods: Sixteen patients (9 females aged 66.0±9.5 years, and 7 males aged 70.7±13.0 years) with intracerebral hemorrhage were examined approximately one week (7.6±1.6 days) after symptom onset. Subjects were imaged on a 1.5T GE Signa Excite scanner. Low flip angle (5º) proton density weighted (PDW) images together with the matching baseline scans (i.e. prior to contrast arrival) from the DCE-MRI scan (flip angle 30º) served to map the native T1 times using a double-angle method. Scan parameters were identical for the PDW and DCE-MRI scans except for the flip angle and were as follows: axial spoiled gradient echo sequence (TR/TE 7.8/3.4ms, slice thickness 5mm, 12 slices, FOV 220mm, matrix size 256x256, temporal resolution 14 sec/vol). Following the PDW scan, 0.1 mM/kg Gd-DPTA was administered and DCE MRI images were obtained over a 420sec period. Thereafter, motion correction and coregistration were performed using in-house software developed in MATLAB (Mathworks, Natick, MA). Data were processed using CINETool, an investigational pharmacokinetic analysis software (GE Healthcare, Waukesha, WI). Two-compartment pharmacokinetic model parameters (forward leakage rate Ktrans, leakage space volume ve and fractional plasma volume fpv) were derived using the dynamics of Gd-DTPA in the brain tissue (Fig 1) [2]. Vascular input function (VIF) was measured by semiautomatic selection of a region of interest in the sagittal sinus. The lesion region of interest (ROI) was selected to cover the entire rim surrounding the hematoma. A control ROI was placed on the homologous location on the contralateral side. Parameter values obtained from the lesion and control ROIs were analyzed using Wilcoxon signed rank test.

Results: Areas of increased permeability were identifiable on the color-coded Ktrans maps (Fig 2). Comparison of the model parameters Ktrans and ve revealed a significant difference between the lesion and control ROIs. The median(IQR) forward leakage rate for the lesion ROI was 0.049 min⁻¹ (0.016-0.075) and median(IQR) forward leakage rate for the control ROI was 0.003 min⁻¹ (0-0.013) (p<0.001) (Fig. 3). Half of the patients had no BBB leakage (Ktrans=0 min⁻¹) in their control ROI and the others had some increase in BBB permeability in their control ROIs, which was significantly less than in their lesion ROIs (p=0.008).

Discussion and Conclusion: This study shows that DCE MRI may be used to assess BBB permeability following ICH. BBB permeability is significantly increased in the region immediately surrounding the hematoma 1 week after ICH onset. The relationships between loss of BBB integrity measured by DCE MRI, perihematomal injury and clinical outcome following ICH need further study.

References:

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