Combined Diffusion and Perfusion MRI in Acute Ischemic Stroke: Correlation to Clinical Outcome


Introduction

Diffusion weighted magnetic resonance imaging (DWI) and perfusion weighted magnetic resonance imaging (PWI) detect ischemic changes in brain within minutes from the onset of ischemia (1). If the hypoperfused tissue on PWI is larger than the infarct on DWI (perfusion-diffusion mismatch) this may represent potentially salvageable tissue, the ischemic penumbra. Combined DWI and PWI may provide valuable information in understanding the pathophysiology and treatment strategies of acute ischemic stroke (2,3).

The purpose of the present study was to evaluate the potential of combined DWI and PWI in predicting the infarct growth and clinical outcome.

Patients and methods

Patients. Thirty-four patients (16 men, 18 women, age 48-87 yrs, mean age 70.7 yrs) with ischemic stroke were studied within 24 hours of symptoms onset. The National Institute of Health Stroke Scale (NIHSS) scores on admission day ranged from 0 to 23 (mean 11.1). Informed consent was obtained from the patient or the patient’s family. The study design was approved by the Ethics Committee of our institution.

Imaging Protocol. MRI was performed on the admission day, on the second day and after one week with a 1.5T scanner (Siemens Vision, Erlangen, Germany). Each imaging session included DWI, PWI, PD-, T2-, and T1-weighted imaging and 2D phase contrast angiography, total imaging time being 20 minutes.

Diffusion Weighted Imaging. DWI was performed using a single-shot echo planar spin echo sequence. Diffusion gradients (b-value 1000 s/mm²) were applied sequentially along three orthogonal axes yielding three diffusion weighted images per slice. Nineteen 5 mm thick slices with 1.5 mm gaps were obtained. Acquisition time was 20 s. Other imaging parameters were TR 4000 ms, TE 103 ms, FOV 260 mm, matrix 96*128. Diffusion trace images were calculated as an average of all three diffusion weighted images. The volumes of tissue with decreased diffusion were determined from the trace images by manually drawing regions of interest.

Perfusion Weighted Imaging. Echo planar spin echo sequence was used in PWI (TR 1500 ms, TE 78 ms, FOV 260 mm, matrix 116*256). Seven 5 mm thick slices with 1.5 mm gaps were imaged from the positions containing the largest diffusion defects. Forty images per slice were acquired with 1.5 second intervals. A 0.2 mmol/kg dose of gadopentetate dimeglumine (Magnevist, Schering AG, Berlin, Germany) was injected into an antecubital vein (rate 5 ml/s) with an MR compatible power injector.

Perfusion raw images were postprocessed to generate maps of relative cerebral blood volume (rCBV), relative cerebral blood flow (rCBF) and mean transit time (MTT). rCBV was determined pixel by pixel by numerical integration of the first-pass concentration-time curve. rCBF was determined by deconvolving the tissue concentration-time curve with the arterial input function to determine the tissue impulse response; rCBF was then determined as the height of the deconvolved tissue impulse response (4,5). The tissue mean transit time was calculated according to the central volume theorem as the CBV/CFB ratio. Volumes of hypoperfused tissue were determined by manually drawing regions of interest.

Assessment of the Clinical Outcome. Before each imaging, the patient’s neurological status was assessed with NIHSS. For statistical purposes, worsening in early clinical outcome (1 week) was defined as an increase of at least two points in the NIHSS.

Results

In acute ischemic stroke, infarct on DWI may grow even after 24 hours from the stroke onset. PWI shows larger perfusion defect than the infarct detected by DWI suggesting the presence of tissue at risk. MTT maps show larger and CBV maps show smaller perfusion defects than CBF maps on the first day. The size of the perfusion-diffusion mismatch predicts the potential of infarct growth. The imaging findings correlate with the neurological outcome and may predict the evolution of neurological deficit.

References


A seventy-one year old female with right hemiparesis and aphasia. On the first day, DWI (left) shows a hyperintense lesion on the left hemisphere representing an infarct. In the same imaging session, PWI detects larger perfusion defect demonstrated in the rCBF map (middle). After one week, DWI (right) shows enlargement of the infarct with some hemorrhagic transformation (the dark region anteriorly within the infarct). NIHSS was 22 on the first day and 26 after one week.