Prognostic Utility of Diffusion Tensor Imaging and MR Tractography in Stroke Patients

H. A. Parmar[1], X. Golay[1], F. Hui[1], Y-Y. Sitoh[1]

[1]Neuroradiology, National Neuroscience Institute, Singapore, Singapore, Singapore

Introduction:

Although there have been many studies on the application of the newer MR techniques of diffusion weighted imaging (DWI) and perfusion imaging in acute stroke, few studies have applied MR techniques to study the clinical outcome in this group of patients (1, 2). With diffusion tensor imaging (DTI) technique, the micro-structural organisation of white matter tracts can be obtained giving important information about their integrity and orientation, something that is not possible on conventional MR imaging. At higher field strength (3 Tesla), the signal to noise ratio and spatial resolution is significantly improved with better visualisation of these fibre tracts. We highlight the potential importance of MR tractography in visualising the morphologic correlate of dysfunctional pathways after cerebral infarction and its potential towards prognostication of patient recovery.

Methods:

Six patients with stroke (four ischemic, two haemorrhagic) were scanned on a 3T system (Intera, Philips Medical System, Netherlands) using a quadrature head coil. DTI scans were performed using echo planar single shot technique at these parameters: TR/TE/flip angle of 6000/88/90, b value 800 s/mm2, 6 directions, 6 NSA, 128 x 96 matrix zero filled to final resolution of 128 x 128, thirty-six axial slices at 3mm slice thickness without any interslice gap in a scan time of 5 min 10 sec. The time of imaging varied from under 1 week to more than eight weeks after the onset of acute symptoms. The apparent diffusion coefficient (ADC) and fractional anisotropy (FA) values were measured in all patients in the regions of infarctions and the involved white matter tracts (corticospinal tract – CST in four, optic radiation in two patients) and were compared with the corresponding regions of the contra-lateral normal hemisphere. MR tractography of the white matter tracts was performed offline on a workstation (PRIDE, Philips Medical System, Netherlands) using the methodology and FACT algorithm described by Mori et al (3). Three-dimensional DTI-based colour maps were also generated (4).

Results:

Of the four patients with ischemic stroke, three had infarcts in the middle cerebral artery (MCA) distribution, while one had posterior cerebral artery (PCA) infarction. Of the two patients with haemorrhagic stroke, one had a basal ganglia hematoma and the other a temporal lobe hematoma. Conventional MR images were abnormal in all. In two cases of infarction imaged acutely, ADC was decreased in the infarcted area (58 to 60 % decrease), while they were increased in the two patients imaged beyond the acute to subacute period. FA values in the CST and optic radiation were reduced by 30-48 % compared to the corresponding sites of the tracts in the contra-lateral hemisphere. MR tractography showed disruption of the CST in the region of the infarct in two patients with MCA infarcts. The CST in one patient was distorted due to the mass effect and tissue oedema, but was otherwise preserved. The patient with PCA territory infarction showed disruption with loss of continuity of the terminal fibres of the involved optic radiation. In both patients with haemorrhagic stroke, susceptibility from the hematoma did not hamper data acquisition and tractography in both patients showed displacement of the CST (Fig 1) and optic radiation respectively. On follow-up, all the patients with displacement of the tracts showed good recovery in their neurological symptoms. Cases with involvement of the CST showed minimal improvement in their hemiparesis and continued to have residual motor deficits (limb power ranging from 2-3/5) on the affected side, even at 12 months follow-up. The patient with PCA infarction developed permanent blindness.

Conclusion:

DTI can visualise and quantify the changes in the integrity and orientation of the white matter tracts that are transected by focal ischemic lesions, which are otherwise not shown on conventional MR imaging or conventional isotropic DWI scans. With MR tractography, visualisation of white matter tracts and the ability to distinguish between distortion or destruction of white matter tracts by oedema or infarction is possible, even in hemorrhagic strokes. The clinical outcome of a patient from a particular infarction may be predicted. Our results also show that small haemorrhagic lesions do not adversely affect diffusion tensor imaging.

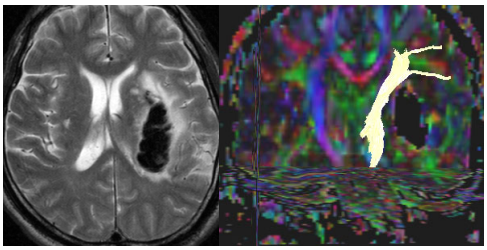

Fig 1 Axial T2W image (left) shows large left basal ganglia hematoma with mass effect distorting the anatomy, location of left CST is not evident. MR tractography (right) shows left CST displaced by the hematoma.

References:

1. Gillard JH, Papadakis NG, Martin K, et al. Br J Radiol 2001;74:642-647
2. Yamada K, Mori S, Nakamura H, et al. Stroke 2003;34:E159-62
3. Mori S, Crain BJ, Chacko VP, van Zijl PC. Ann Neurol 1999;45:265-269
4. Basser PJ, Pajevic S, Pierpaoli C, Duda J, Aldroubi A. Mag Reson Med 2000;44:625-632