Diffusion tensor imaging assessment of the white matter in preterm infants who show diffuse white matter changes on conventional magnetic resonance imaging at term equivalent age

S. J. Counsell[1], J. P. Boardman[2], Y. Shen[1], O. Kapellou[2], D. J. Larkman[1], J. M. Allsop[1], J. V. Hajnal[1], D. Edwards[2], M. A. Rutherford[1]

[1]Robert Steiner MR Unit, Imaging Sciences Department, Clinical Sciences Centre, Hammersmith Hospital, Imperial College London, London, United Kingdom, [2]Department of Paediatrics, Hammersmith Hospital, Imperial College London, London, United Kingdom

Introduction

Both conventional and diffusion weighted magnetic resonance (MR) imaging studies have demonstrated white matter changes in the majority of preterm infants at term equivalent age (1,2). However, our previous diffusion weighted imaging study was not able to assess diffusion anisotropy, the directional dependence of water diffusion in a restricted environment. Diffusion tensor imaging (DTI) has previously been used to assess brain tissue microstructure in preterm infants (3,4,5), and this technique may provide further insight into the nature of diffuse white matter disease in this patient group.

Aim

The aim of the present study was to test the hypothesis that relative anisotropy (RA) values were significantly different in the white matter in preterm infants with diffuse excessive high signal intensity (DEHSI) on T2 weighted imaging compared to both preterm infants with normal appearing white matter and to term born control infants.

Subjects

Ethical permission for this study was granted by the Hammersmith Hospital Research Ethics Committee. Infants with focal lesions demonstrated on MR imaging were excluded from the study. The study group consisted of 33 preterm infants and 6 term born control infants. The median (range) gestational age at birth of the preterm infants was 31 (25 – 34) weeks and of the term born control infants was 38 (37 – 41) weeks. The median (range) birthweight of the preterm infants was 1.45 (0.61 – 2.23) kg and of the term born control infants was 3.52 (3.34 – 4.7) kg.

The preterm infants were divided into 2 groups on the basis of their conventional MR imaging without knowledge of their DTI results. Group 1 = those with normal appearing white matter Group 2 = those with evidence of DEHSI on T2 weighted MR imaging.

The data were analysed using a one-way ANOVA with a Bonferroni correction for multiple comparisons.

Methods

MR imaging was obtained on a 1.5 T Philips Eclipse system using a dedicated paediatric head coil. DTI was acquired in 6 non-colinear directions with the following pulse sequence parameters; TR 6000ms, TE 100ms, field of view = 24cm, slice thickness = 5mm, matrix = 100 x100, b = 710 s/mm^2. Regions of interest (ROIs) were positioned in the anterior, central and posterior white matter at the level of the centrum semiovale bilaterally. ADC and RA values were calculated off line using an in house developed programme, which corrects for high order eddy current distortions (6). Mean ADC and RA values were calculated for the 6 ROIs in the white matter of the centrum semiovale to give one value for this region.

Results

Seven preterm infants had normal appearing white matter and 26 had evidence of DEHSI on conventional MR imaging. The median post menstrual age at the time of scanning of the infants with normal appearing white matter was 41 (38 - 42) weeks, of those with DEHSI was 40 (39 –43) weeks and of the term born control infants was 40 (38 – 41). These were not significantly different.

There was no significant difference in ADC ($p > 0.99$) or RA ($p > 0.99$) values between normal preterm infants (group 1) and term born control infants. However, ADC values were elevated and RA values were reduced in the white matter of preterm infants with DEHSI (group 2) compared to group 1 (ADC, $p = 0.003$; RA, $p = 0.02$) and term born control infants (ADC, $p < 0.001$; RA, $p = 0.003$).

Conclusions

The reduction in RA and elevation in ADC values in infants with white matter disease suggests microstructural abnormalities within the white matter which may be due to oligodendrocyte damage, reduced axonal diameter, a reduction in the number of axons or less coherently organised fibre bundles. RA and ADC values in preterm infants with normal appearing white matter on conventional MR imaging are similar to those of term born control infants, and so preterm birth *per se* is not necessarily associated with abnormal white matter development.

References

1. Maalouf et al, Journal of Pediatrics, 1999.
2. Counsell et al. Pediatrics, 2003.
3. Neil et al. Radiology, 1998.
4. Huppi et al. Pediatric Research, 1998.
5. Miller et al. Journal of Magnetic Resonance Imaging, 2002.
6. Shen et al. Proc ISMRM, 2003: 1035.

Acknowledgements

Medical Research Council, Philips Medical Systems, Academy of Medical Sciences, The Health Foundation, Garfield Weston Foundation.