MRI Quantification of Brain Water Diffusion in Nonpregnant, Pregnant, and Postpartum Women

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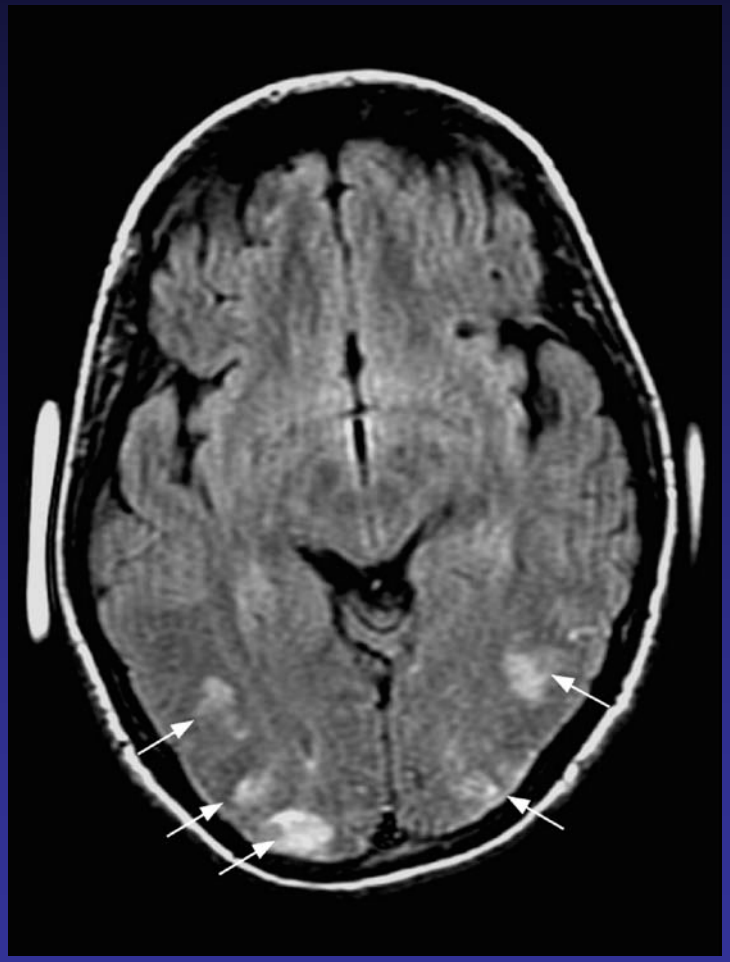
Background

- Pregnancy and its increase in cardiac output poses a unique challenge to maternal cerebral vascular adaptation.

- Eclampsia is characterized by reversible posterior brain edema. (1)

1. Bernstein IM, Cipolla MJ Fetal and Maternal Medicine Review 2008;19:85

MRI of the brain (axial FLAIR sequence) at initial presentation showing patchy parieto-occipital increased signal (arrows) following postpartum eclamptic seizure



Mehta H et al. Postgrad Med J 2008;84:555-557

Background

- Animal models demonstrate that pregnancy predisposes to brain edema formation in the presence of hypertension (2)

- We have hypothesized that the normal physiologic changes associated with pregnancy, when super-imposed on specific prepregnancy phenotypes results in the preeclampsia/eclampsia syndrome (3)

2. Euser AG, Cipolla MJ. HTN 2007;49(2):334-40
3. Bernstein IM et al Obstet Gynecol 1998;92:306-8

Objective

- **Specific**
  - The objective of the current study was to quantify properties of cerebral water movement comparing women in the third trimester of uncomplicated pregnancy (P) with nulligravid (N) and post-partum (PP) women estimating mean water diffusivity and fractional anisotropy within distinct regions of the brain employing high-resolution MRI.

Outcome Measures

- Mean Diffusivity:
  - This measurement can reflect changes in extracellular water, intracellular water and/or the movement of water across membranes. Brain edema or increased water content in a volume of brain tissue is associated with less restriction to water movement or increased overall mean diffusivity
- Fractional Anisotropy:
  - This measurement reflects the directionality of water movement within regions of the brain. Edema can be associated with less restriction and directionality to water movement within a volume of brain tissue leading to reduced anisotropy.

Methods-Subjects

- Study subjects
  - 14 young healthy women (mean + s.e.m.)
    - 5 non pregnant, nulligravid (luteal phase)
    - 5 pregnant, primigravid (34.9 $\pm$ 2.2 weeks)
    - 4 postpartum, primiparous (39 $\pm$ 11 weeks)
- Subjects were recruited by newspaper and posters ads
- Non-smokers
- No hypertension, diabetes, autoimmune disease or other major medical conditions
- No routine medications

Subjects
(characteristics)

	Non-pregnant (n=5)	Pregnant (n=5)	Postpartum (n=4)
Age (years)	31.6 ± 1.7	32.2 ± 3.3	30.0 ± 2.2
MAP (mm Hg)	83.7 ± 6.2	89.1 ± 3.6	81.8 ± 1.3
BMI (kg/m^2)	21.3 ± 1.2	22.4 ± 4.7	25.1 ± 0.9

Methods-Subjects

- Studies were performed on a 3.0T Philips Achieva MR system with routine multiplanar MR sequences along with diffusion tensor 32 direction sequence.

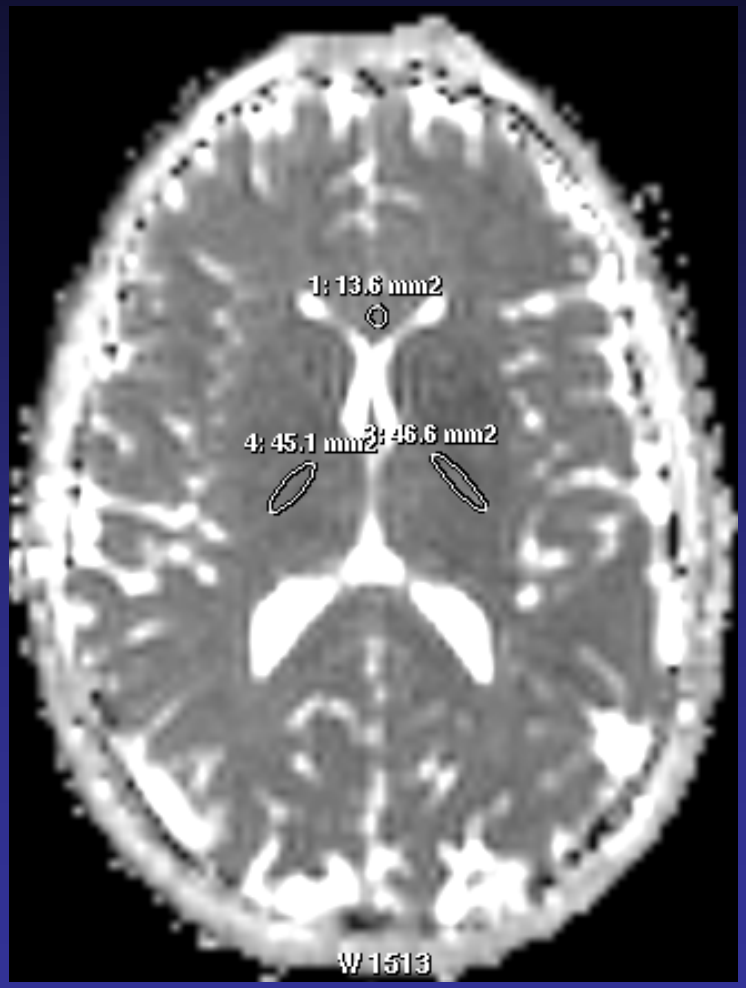
- Mean values of diffusivity were derived on an independent work station (Philips, Best Netherlands).

- Region of interest measurements were obtained in the genu of the corpus callosum and bilaterally within the posterior limb of the internal capsule, posterior frontal, posterior temporal, parietal and occipital subcortical white matter.

Apparent Diffusion Coefficient Map

Region of interest measurements for the mean diffusivity within:

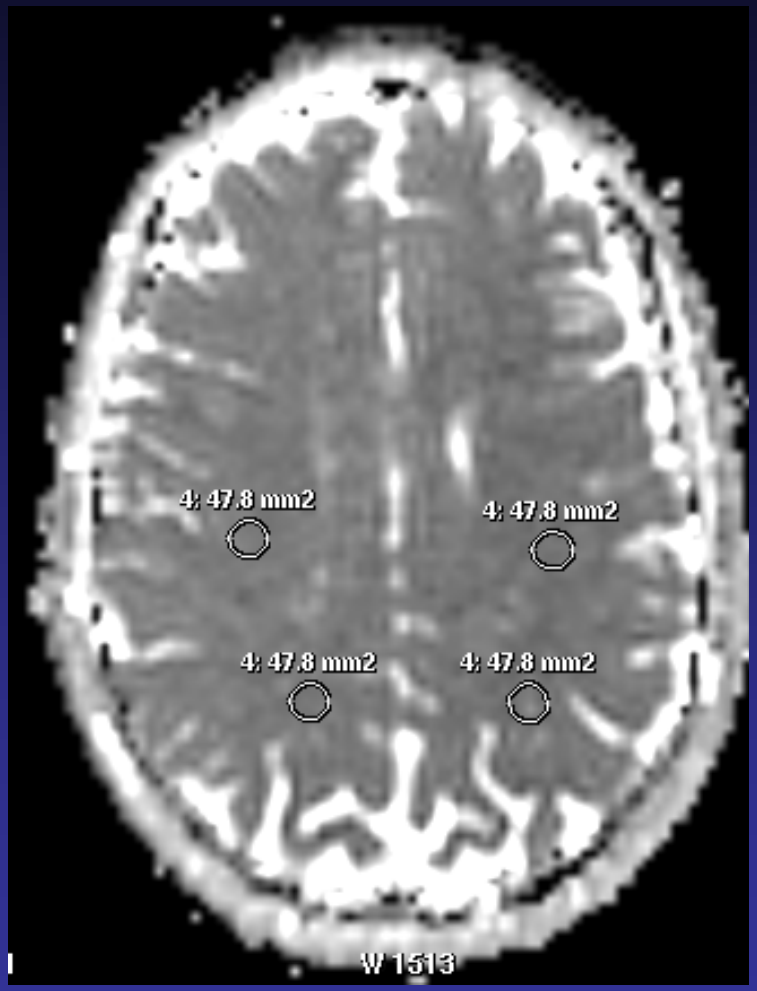
1) genu of corpus callosum
2) posterior limb of the internal capsule bilaterally



Apparent Diffusion Coefficient Map

Region of interest measurements for the mean diffusivity within:

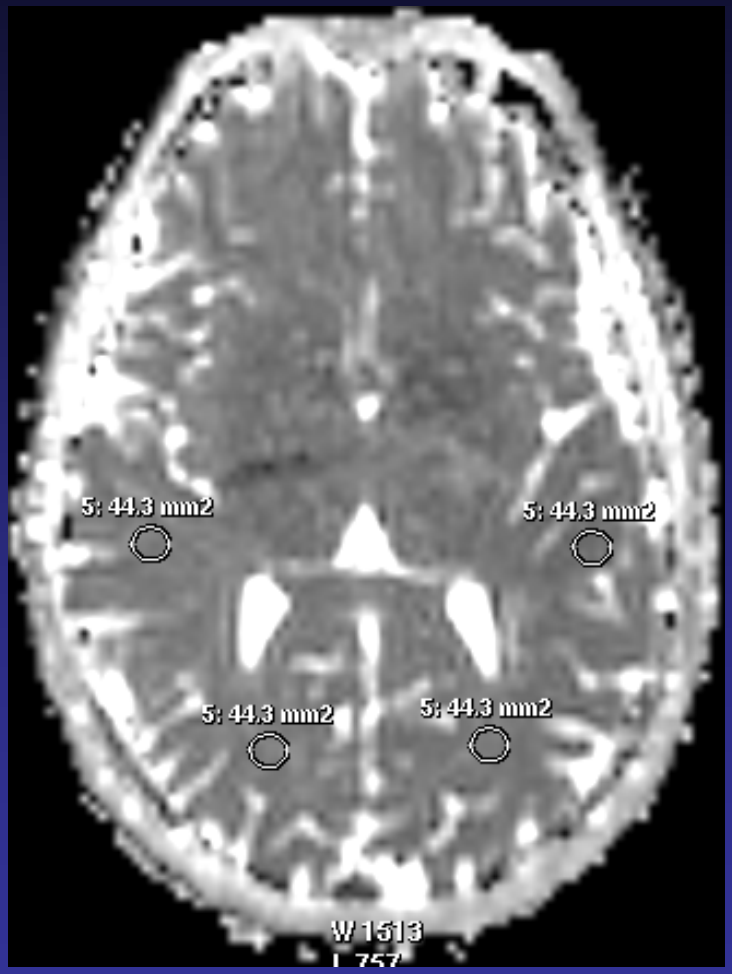
1) posterior frontal subcortical white matter.
2) parietal subcortical white matter.



Apparent Diffusion Coefficient Map

Region of interest measurements for the mean diffusivity within:

1) posterior temporal white matter
2) occipital subcortical white matter.



Results: Mean Diffusivity

Subjects	Post Limb Internal Capsule	Post Frontal Subcortical White	Post Temp Subcortical White	Parietal Subcortical White	Occipital Subcortical White
Non-pregnant	0.71 ± .04	0.71± .04	**0.73 ± .05** A	**0.74 ± .03** A	**0.75 ± .05** A
Pregnant	0.71 ± .04	0.71 ± .05	**0.77 ± .04** B	**0.79 ± .05** B	**0.81 ± .06** B
Post-partum	0.70 ± .06	0.69 ± .04	**0.78 ± .04** B	**0.75 ± .04** A	**0.75 ± .04** A

Different letters designate differences within brain regions between groups $p<0.05$

Results: Fractional Anisotropy

Subjects	Genu Corpus Callosum	Post Limb Internal Capsule	Post Frontal Subcortical White	Post Temp Subcortical White	Parietal Subcortical White	Occipital Subcortical White
Non-pregnant	**0.83 ± .05** A	0.77 ± .05	0.55 ± .07	0.58 ± .05	0.59 ± .05	0.62 ± .08
Pregnant	**0.78 ± .06** B	0.74 ± .06	0.55 ± .06	0.60 ± .07	0.57 ± .06	0.64 ± .06
Post-partum	**0.79 ± .05** B	0.76 ± .03	0.53 ± .06	0.59 ± .08	0.57 ± .06	0.64 ± .06

Different letters designate differences within brain regions between groups $p<0.05$

Summary

- Pregnant women demonstrate significant increases in mean water diffusion in the brain when compared to nulligravid controls.
- We noted a reduced anisotropic index in the highly organized tracts within the genu of the corpus collosum.
- The differences in mean diffusivity were particularly noted in the posterior and parietal regions.
- Some of these changes appears to persist for a significant length of time postpartum.

Conclusions

- The measurement of mean brain water diffusivity can reflect increases in extracellular water, intracellular water and/or the movement of water across membranes. Although not specific, increases in this measure are consistent with changes in brain edema.

- The regional increases in water diffusivity noted in normal pregnancy may contribute to an increased likelihood of cerebral edema formation when hypertension complicates pregnancy.