The clinical use of MR Angiography in neonatal cerebral vessel imaging during normal development

Malamateniou C, Counsell SJ, Allsop JM, Fitzpatrick JA, Cowan FM, Rutherford MA, Hajnal JV
Robert Steiner MRI Unit, Imaging Sciences Department, Hammersmith Hospital

Introduction

There is a high incidence of neurodevelopmental impairment following preterm birth. The anatomical substrates for motor disorders are well recognised but there are as yet no correlates for the neurocognitive disorders associated with prematurity. Previous MRI studies reported that premature exposure to the ex-utero environment alters brain development. The role of vascular development in these alterations is not known.

To date and to our knowledge there have been no systematic MR Angiography (MRA) studies to explore the effect of prematurity on neonatal cerebral vasculature.

Aims

To study the effect of preterm birth on the morphology of the neonatal cerebral vasculature as assessed by MRA at 3 Tesla.

To perform longitudinal studies and explore whether this vascular phenotype persists over time.

To correlate this finding with other markers of brain development

Methods

Sample size and exclusion criteria

A total of 62 infants, 37 term born and 25 preterm at term equivalent age have been scanned using an optimised dedicated MRA protocol for neonates. We excluded infants with motion artefacts and primary vascular disease. Postmenstrual age at scan was not statistically different between the two groups. Longitudinal MRA images were available for 10 infants. Qualitative and quantitative assessment of all images was performed.

Image analysis

Qualitative

Images have been assessed qualitatively to identify anatomic variations of the circle of Willis (figure 1) and to detect vessel structural changes in normal development.

Quantitative

Images have been analyzed using ImageJ medical Image analysis software for assessing vessel calibre, vessel distance factor as a measure for tortuosity and neonatal head biometry such as head circumference, biparietal and fronto-occipital head diameter (figure 2).

Statistics

The Shapiro-Wilk test was used to check for normality. Paired t-test was used for the longitudinal studies and unpaired t-test and Mann-Whitney test for the group comparisons as appropriate.

Results

Qualitative assessment

Cerebral vessels were less tortuous in the preterm infants imaged at term in comparison to the term-born controls (figure 3). This finding was shown to persist over time by visual inspection (figure 5). The vessels of the preterm infants also appear simpler and look sparser in the periphery, with fewer visible branches and bifurcations. This was observed in the transverse plane but confirmed visually in the other planes (figure 4) for all the arterial segments: anterior, middle and posterior cerebral arteries. Differences in the occurrence of anatomic variations and the completeness of the Circle of Willis was noted between preterm at term and term infants.

Quantitative assessment

There was no significant difference between the preterm at term and the term infants in vessels diameter. Preterm infants had significantly less tortuous vessels and smaller biparietal head diameters (table 1).

Conclusion

• This study has shown that the preterm cerebral vasculature is also altered by the ex-utero environment. The preterm infants' proximal cerebral vessels imaged at term age were of similar calibre but less tortuous than those of the term born patient control infants. Differences in the anatomic variations of the Circle of Willis were also observed.

• This vascular phenotype was observed in all three imaging planes and persisted over time, as qualitative and quantitative studies showed.

• Tortuosity in the middle cerebral arteries of both the term and the preterm infants imaged at term had a negative correlation with biparietal diameter.

• The aetiology as well as the clinical significance of these findings remain unknown and will be the subject of future neuroimaging studies.

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Table 1

Acknowledgements:

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contact: cm1@ic.ac.uk

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5