Optimisation and clinical applications of neonatal magnetic resonance angiography of cerebral vessels at 3 tesla

Christina Malamateniou
Imperial College London– 2007

ABSTRACT

Background : Magnetic Resonance Imaging (MRI) studies have identified differences in brain development between preterm infants imaged at term equivalent age and term born infants imaged shortly after birth. Magnetic Resonance Angiography studies (MRA) in the neonatal population are scarce and little is known about vascular development in the neonatal brain. Advanced MRA techniques and high field imaging offer a unique opportunity to visualise the small neonatal vasculature. Qualitative and quantitative methods of MRA image analysis could be employed to investigate morphological differences of the neonatal cerebral vasculature between preterm and term infants.

Aims : 1. To create an optimised dedicated neonatal MRA protocol with increased cerebral vessel visibility. 2. To qualitatively and quantitatively analyse the morphological characteristics (vessel diameter, vessel tortuosity, anatomic variations) of the neonatal cerebral vasculature in preterm and term born infants using the optimised MRA protocol. 3. To qualitatively and quantitatively examine the evolution of vascular morphology in the first few months of life.

Hypotheses : 1. Neonatal vascular anatomy and physiology should be taken into account for the construction of a neonatal optimised MRA protocol. 2. There is a distinct cerebro-vascular phenotype associated with preterm birth. 3. This phenotype persists for some time after birth.

Methods : Twenty-six healthy adult volunteers and twenty-five infants of different postmenstrual age were scanned for the construction of the optimised neonatal MRA protocol.
MRA images of 146 neonates (82 term born and 64 preterm at term) were qualitatively and quantitatively analysed. Forty-one infants had at least one successful follow-up MRA scan. All MRA scans were performed at a 3 Tesla MRI scanner.
Qualitative assessment included visual analysis of vessel visibility and of the presence of anatomic variations of the Circle-of-Willis (CoW). Quantitative analysis included vessel diameter and tortuosity measurements and correlation with measured head biometry at scan (head circumference and biparietal/fronto-occipital head diameters).

Results : The small vessel size and slow blood flow of the neonatal cerebral arteries were the two characteristics that steered the construction of the optimised MRA protocol. The optimised neonatal MRA protocol significantly

improved neonatal vessel visibility compared to the standard adult MRA protocols.
MRA image analysis revealed significantly decreased tortuosity in all proximal cerebral arteries of the preterm infants at term compared to their term born counterparts but no differences in vessel diameters between the two groups. Differences in the incidence of certain anatomical variations of the CoW where also observed between the two groups. Significant and strong positive linear correlations were detected of vessel diameter with postnatal factors (such as postmenstrual age, head circumference at scan and weight at scan) and of vessel tortuosity with perinatal factors (such as gestational, head circumference at birth and weight at birth) in the total sample.
In the longitudinal studies vessel diameter and visibility increased with advancing postmenstrual age. Anatomic variations of the CoW did not, generally, change with a few exceptions. Vessel tortuosity did not change in either preterm or term born infants over the time period observed in the follow-up study.

Conclusions :
The use of an optimised MRA protocol designed specifically for neonatal subjects allows significantly more of the cerebral arterial circulation to be visualised allowing effects of prematurity and the incidence of anatomical variations to be detected and analysed with both qualitative and quantitative methods. This analysis confirmed the existence of a distinct cerebrovascular phenotype of decreased tortuosity associated with preterm birth and illustrated the strong influence of gestational age in the development of this phenotype. This finding of decreased tortuosity persisted into early childhood. The origin and clinical significance of these findings remain unknown and it is hoped that further imaging studies could offer useful insights.