Optimised Magnetic Resonance Angiography at 3 Tesla for neonates

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Background

MR Angiography is a well-established technique for imaging brain vessels in various diseases in adult studies. Neonatal MRA has been rather underused, although prevention and treatment of several neonatal pathologies (neonatal stroke, hypoxic encephalopathy) can benefit from the understanding of underlying vascular mechanisms[1]. Neonates have specific physiologic and anatomic features, such as slower blood flow[2] and smaller vessel diameters and they tend to move during the longer scans, which makes neonatal MRA a very challenging application. We have found that preset adult angiographic protocols give inferior results, particularly on premature infants. Therefore neonatal MRA protocols need further optimization. MRA at 3 Tesla is a powerful imaging tool with intrinsically increased SNR that offers the option for further optimization of intra-vascular signal, image resolution and scan duration[3]. To our knowledge no systematic studies of neonatal brain vessels and the Circle of Willis at 3 Tesla have been performed so far.

Methods

We used a 3 Tesla Philips Intera (Best, Netherlands) MRI scanner. The study was approved by the Hammersmith Hospital Research Ethics Committee and informed parental consent was obtained for all of these infants. Subjects were studied using either a transmit/receive or a 6 channel synergy head array coil (MRI Devices Corporation). Both time of flight (TOF) and phase contrast (PC) methods were tested. In a progressive set of examinations the following parameters were adjusted to determine a combination of improved vessel visualisation and decrease in scanning times: TR, Flip angle, TE, number of chunks, velocity sensitivity in PC (venc), SENSE speed-up factor, acquired matrix resolution, number of slices, slice thickness, scan %, full/partial echo, rest slab thickness and gap, fat suppression pre-pulses and cardiac synchronization strategies. Images were processed using Maximum Intensity Projections (MIPs) and assessed qualitatively for conspicuity of vessels and depiction of more distal vessels by two observers (CM, JVH). The optimised protocol was then tested on 17 neonates drawn from a population who were already undergoing MRI for other clinical reasons. One of these infants had to be excluded from the study due to motion artefacts. In each case infants were imaged using the standard adult protocol as well to provide a point of reference. The same anatomic coverage was obtained with both techniques. Contrast to noise ratios (CNR) were measured for the proximal M1 and distal M2 segments of the middle cerebral arteries on the transverse MIPs. All source images were checked for motion prior to qualitative and quantitative analysis.

Results

Initial results with 3D TOF, without optimization, were characterised by blood saturation and limited visualization of the small distal branches of the cerebral arteries. In the optimised TOF MRA protocol I) visual analysis of the MIPs revealed increased vessel conspicuity (number and length of vessels) for the relatively smaller peripheral branches (figure 1 A and B) and ii) CNR measurements on the MIPs were significantly higher for the distal peripheral branches ($p<0.001$). However SNR and scan duration remain limiting factors, particularly in extremely preterm infants, with small vessels. From all the imaging parameters we tested for 3D TOF MRA (table 1), the increase in acquired matrix resolution and the use of multiple chunks had the biggest impact on improving vessel visibility and the implementation of parallel imaging on keeping scanning times within acceptable limits without significantly degrading vessel visualisation. Although PC MRA produced excellent images on some infants, quality was variable depending on the infant's blood flow velocity so that individual choice of venc for each subject appeared to be required. This undermined the utility of the method. Also 3D PC MRA images very often presented with pulsatility artefacts at the level of the internal carotids and venous "contamination" from the transverse sinuses posteriorly (figure 1C).

Discussion

Neonatal angiography requires different parameters than those used for adults. Optimisation in a fast developing brain requires fine adjustments, which may need to be age appropriate. PC angiography was particularly problematic in this regard. In general, the slower flow and reduced vessel size appear to be particularly important factors. 3T imaging with SENSE was particularly helpful in this regard. Having achieved improved visualisation of vessels, we are now applying the methods to the study of neonatal vessel growth and development, as well as performing quantified studies of vessel shape and size in both normal neonates and those with pathology.

References

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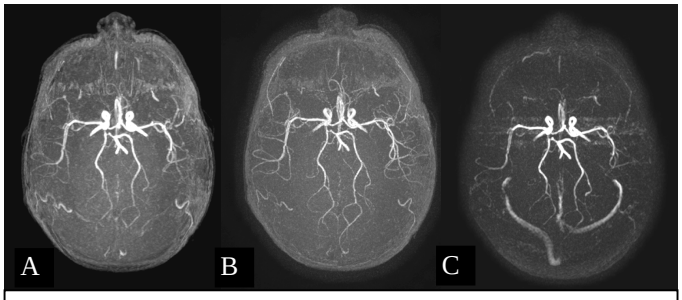

Figure 1.From left to right: (A) preset 3D TOF MRA, (B) optimised 3D TOF MRA, (C) 3D PC MRA of the same infant. Superior vessel conspicuity observed in the optimised TOF protocol. All images were acquired with the same anatomic coverage craniocaudally. For the 3D PC MRA the results have been very variable, whereas 3D TOF MRA was quite robust.

PROTOCOL PARAMETERS	preset	optimised
TR/TE/FA	MIN/MIN/20	20/3.5/16
FOV/RFOV	160/100%	160/80%
SCAN %	64%	100%
SLICES	100	100
THICKNESS	1.2	0.6
ACQUIRED.RESOLUTION	0.53x0.82x1.2 mm^3	0.6x0.6x0.6 mm^3
ECHO	PARTIAL	FULL
ANAT.COVERAGE	6CM	6CM
SENSE SPEED FACTOR	1	2
Scanning time	5:11mins	5:16mins

Table 1