Whole body post-mortem fetal magnetic imaging at 9.4T: A rapid and less invasive autopsy for small foetuses

S. Thayyil[1], J. Cleary[2], A. N. Price[2], R. Jones[1], N. Sebire[3], N. Robertson[4], M. F. Lythgoe[2], and A. Taylor[1]

[1]Centre for Cardiovascular MR, UCL Institute of Child Health, London, London, United Kingdom, [2]Centre for Advanced Biomedical Imaging, UCL Institute of Child Health and Department of Medicine, London, United Kingdom, [3]Histopathology, Great Ormond Street Hospital NHS Trust, London, United Kingdom, [4]Obstetrics and Gynaecology, UCL Institute of Womens Health, London, United Kingdom

))

Whole body magnetic resonance imaging (MRI) at 1.5 T is increasingly used for a "less invasive autopsy" in foetuses[1]. However, it is difficult to obtain images of sufficient resolution and quality for accurate radiological diagnosis on foetuses of less than 20 weeks In our experience, the number of averages, and thus acquisition time, required to produce images of sufficient quality is not practical on a clinical system . While whole body high resolution MRI at 9.4T has been successfully done in small animals, this has not been reported in human foetus.

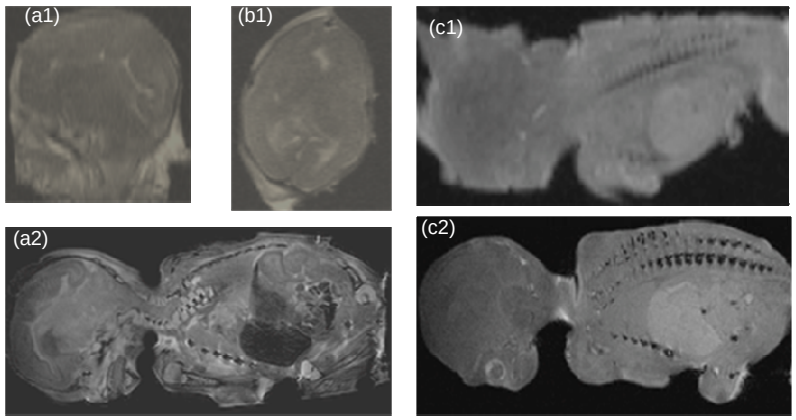
Aim To examine the feasibility of whole body fetal MR scanning at 9.4T and to compare the images with 1.5T MR and histopathology.

Methods 4 foetuses (14,16,17 and 19 weeks gestation) were scanned on 9.4T Varian VNMRS scanner (40G 115mm gradient set, 72mm volume coil [Rapid Biomedical GmbH]) and a 1.5T Siemens Avanto scanner. A 3D T2 weighted fast spin echo (FSE) sequence and a 3D Flash sequence were used for the whole body imaging, in both scanners.

9.4T parameters: *Case 1:* T2 images: FSE3D 256x128x64 (400mμ isotropic) TR=500ms, ETL=8, ESp=20ms, TE eff=120ms Tacq=8min 32sec; T1 images: MP-RAGE 256x128x64 (400mμ isotropic) TE=1.78ms, TR=10ms, Flip Angle=10*,NA=1 with TIs=600ms & 1000ms (TIeff=1240ms & 1640ms) *Case 2-4:* T2 images FSE3D 256x128x128 (400mμ isotropic) NA=1, Tacq=17mins 4sec and at 512x256x256 (200mμ isotropic) Tacq=1hr 8min 16s.

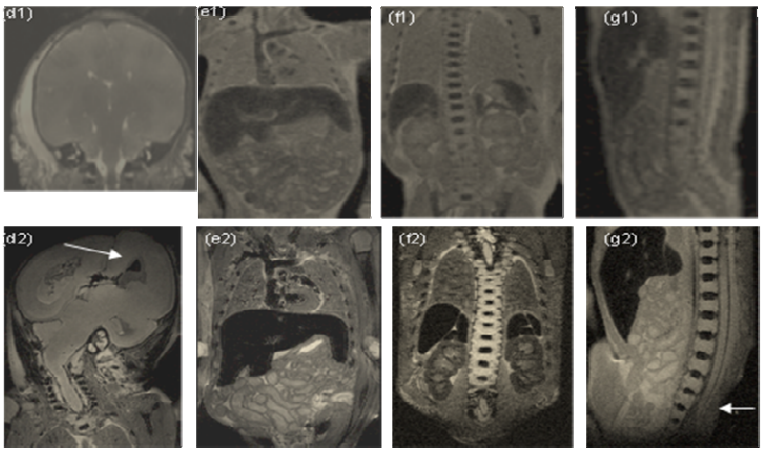
1.5T parameters: TR 3500, TE 360, Flip angle 120, ETL 169, Averages 3, Slice thickness 1.2 mm, Acquisition time 22 minutes and a carotid coil was used. Full autopsy and histo-pathological examination were done following MRI. The study was approved by GOSH-ICH research ethics committee and was funded by department of health. Parental consent was obtained for the research and publication of images.

Results Excellent contrast and resolution depicting normal anatomy and pathology was obtained by the 9.4T scan (figures a2 to g2). Image resolution at 1.5T was poor and rendered the images non-diagnostic at this field strength. Autopsy on case one was normal apart from autolysed brain. Case 2 had Arnold Chiari malformation Type II and spina bifida. Signal to noise ratios (SNR) were calculated for whole brain, cortical grey, liver, lung, spine and eye from the T2-weighted images. On average the SNR in case 1 at 1.5T was 70 and at 9.4T was 25 ($p<0.05$). In case 2 the SNR were similar: 30 at 1.5T and 35 at 9.4T ($p=0.8$). SNR was greater for 1.5T in case 1 due to the lower resolution. However, this increase in SNR did not improve detectable pathology in case 1.



Case 1: 14 week foetus

Figure (a1, b1): 3D FSE T2 weighted coronal and axial images at 1.5 T. Difficult to delineate anatomy. (c1): 3D Flash T1, limited tissue differentiation. (a2): 3D FSE T2 at 9.4T showing good tissue contrast. (c2): 3D Flash T1 at 9.4T. Contrast is limited, but better than 1.5T



Case 2: 19 week foetus (termination of pregnancy)

Figures (d1, e1, f1, g1) and (d2, e2, f2, g2) show coronal and sagital images at 3D FSE T2 weighted coronal image at 1.5T and 9.4T respectively. Note the small posterior fossa, angulation of ventricles and herniation of cerebellum indicating Arnold Chiari Type II, clearly depicted on 9.4T (White arrows on d2). Spinal defect seen (white arrows) on g2. Figures d2, e2 and g2 are at 400 microns and f2 is at 200 microns resolution.

Conclusion These cases represent the first post-mortem fetal images at 9.4T, and demonstrate that excellent tissues characterisation of whole body of human fetuses less than 20 weeks can be rapidly obtained at this field strength. This technique is potentially useful as an adjutant to or replacement for autopsy in small fetuses. Further study to optimise sequence parameters and to confirm the accuracy of post-mortem MR diagnosis at 9.4T in comparison with conventional post-mortem assessment is now necessary.

Reference: 1. Cohen M et al Less invasive autopsy. Benefits and limitations of of the use of magnetic resonance imaging in perinatal post-mortem. Pediatric Developmental Pathology 2007 (March 22)