Optimisation of a Balanced Fast Field Echo Cine Sequence for the Assessment of Human Fetal Motor Function

T. Hayat1,2, J. Alsop1, A. McGinness3, F. Ferrari1, M. Rutherford1,2, and J. V. Hajnal1

1Robert Steiner MRI Unit, Imaging Sciences Department, MRC Clinical Sciences Centre, Hammersmith Hospital, Imperial College London, London, United Kingdom, 2Perinatal Imaging Group, MRC Clinical Sciences Centre, Hammersmith Hospital, Imperial College London, London, United Kingdom, 3Department of Pediatrics and Neonatology, Modena University Hospital, Italy

INTRODUCTION
The assessment of motor function in neonates may provide important developmental information. A movement pattern, known as General Movements (GM), is clinically useful in diagnosing abnormal neurological conditions in preterm and term-born infants [1]. To accurately assess GM it is necessary to view the whole infant [2]. Fetal movements have also been studied in utero using 3D and 4D ultrasound (US) and GM have been identified [3]. However, the limited field-of-view afforded by the US transducer prevents full visualisation of the fetus from 20 weeks gestation (GW). MRI can visualise the whole fetus even in late stages of pregnancy and has the ability to achieve sufficient temporal resolution to generate cine data depicting human fetal movements in detail. The aims of this study were to optimise a cine sequence for imaging the whole fetus throughout gestation and to apply this in a pilot study of fetal movement.

METHODS
22 fetuses were imaged for sequence optimisation which was then used prospectively in a further 51 fetuses. MR exams were performed on a 1.5-Tesla Achieva scanner (Philips Healthcare, the Netherlands) using a 5-channel phased array cardiac coil. After initial trials a multi-slice balanced fast field echo (B-FFE) sequence was selected for optimisation. The repetition and echo times (TR and TE) were adjusted to optimise temporal and spatial resolution.

RESULTS
Optimisation of Cine Sequence

Fig 1 Frames 123, 129, 135 of a fetus rotating during a GM.

Analysis of Fetal Movements

20 datasets were discarded as they were were of insufficient duration. 31 datasets were used for movement analysis, distributed as shown in Table 1. The following movement patterns were identified: GM, isolated extensions, flexions and rotations in all limbs, head and trunk, mouthing, swallowing, breathing, eye movements and startles. Data were first analysed for the proportion of total imaging time during which the fetus moved (Fig. 2). We found a statistically significant reduction in movement in both the normal>30GW (p<0.05) and intra-uterine growth restricted (IUGR)<30GW (p<0.05) subsets when compared to the normal<30GW subset. No significant difference in movement duration was found between the normal<30GW and the ventriculat dilation (VD) <30GW subsets (p=0.27), these were the also the only groups in which we identified GM. Using the GM quality assessment criteria and OLS we found: in the normal sample (N=5), 4 fetuses with normal and 1 poor repertoire; OLS range=14-18 (median=18). In the VD sample (N=5), 4 fetuses had poor repertoire and 1 chaotic; OLS range=11-15 (median=12). Using OLS we found there to be a statistically significant difference in the distribution of scores between these two groups (p<0.05).

CONCLUSIONS
We have sought to systematically address the use of MRI for capturing fetal movements. We have optimised a sequence and documented patterns of fetal movement within clear constraints imposed by sampling limitations with regards to both total imaging time and temporal resolution. Our sequence provides detailed coverage of the whole fetus as at all gestations. Initial data have captured the full repertoire of movement patterns, including unambiguous examples of GM over a range of gestations in normal and abnormal fetuses. A decrease in movement frequency with age was noted, and a difference in the quality of GM between a normal population and one with neurological abnormalities. With increasing numbers we hope to further understand the nature of fetal movements and how they may be increasingly affected both qualitatively and qualitatively by the restrictive uterus as the fetus grows.

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REFERENCES