DTI BASED TRACTOGRAPHY OF FETAL PERIVENTRICULAR CROSSROAD REGIONS IN UTERO

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Introduction:
Various fetal brain abnormalities are associated with MR signal alterations of periventricular crossroad regions. These periventricular white matter areas contain a complex arrangement of intersecting thalamocortical, corticopontine/corticospinal, callosal and cortico-cortical association fiber tracts as well as external capsule fibers (for a review see Judas et al. 2005). Intrauterine white matter lesions in this region lead to motor and sensory deficits but also to problems in higher cognitive functions and behavioral regulation. We used DTI based tractography to segment and characterize individual fiber tracts of the parietal crossroad region in living unsedated fetuses in utero. Our aim was to characterize the 3-dimensional morphology and topographical relations of individual components as well as developmental differences across different gestational ages.

Methods:
7 normal fetuses between gestational week (GW) 20 and 34 were examined in a 1.5 Tesla MR scanner using an axial diffusion tensor sequence (16 diffusion encoding directions, reconstructed voxel size 0.94x0.94x3mm^3, b values of 0s/mm^2 and 700s/mm^2). After geometrical image coregistration with a T2-weighted image, the specific fiber tracts of the parietal crossroad regions were anatomically defined following the available post mortem data, using a multiple ROI approach and calculated using a FACT algorithm (Philips Extended MR WorkSpace 2.6.3.2).

Results:
In accordance with previously published histological data (Judas et al. 2005), we were able to visualize and 3D reconstruct different components of the parietal periventricular crossroad region in living unsedated fetuses in utero. Thalamocortical, corticopontine/corticospinal, external capsule and association fiber tracts could be identified depending on their different position, morphology and course as early as GW 20 and showed a laminar organization with sagittally oriented strata. Fiber tract components of the internal capsule that continued into the cerebral peduncles were identified as corticopontine/corticospinal fibers, while those internal capsule fibers that turned medially into the thalamic region were identified as thalamocortical fibers. External capsule fibers and association fiber tracts were also found to be part of the parietal crossroad region and were located lateral to corticopontine/corticospinal and thalamocortical fibers.

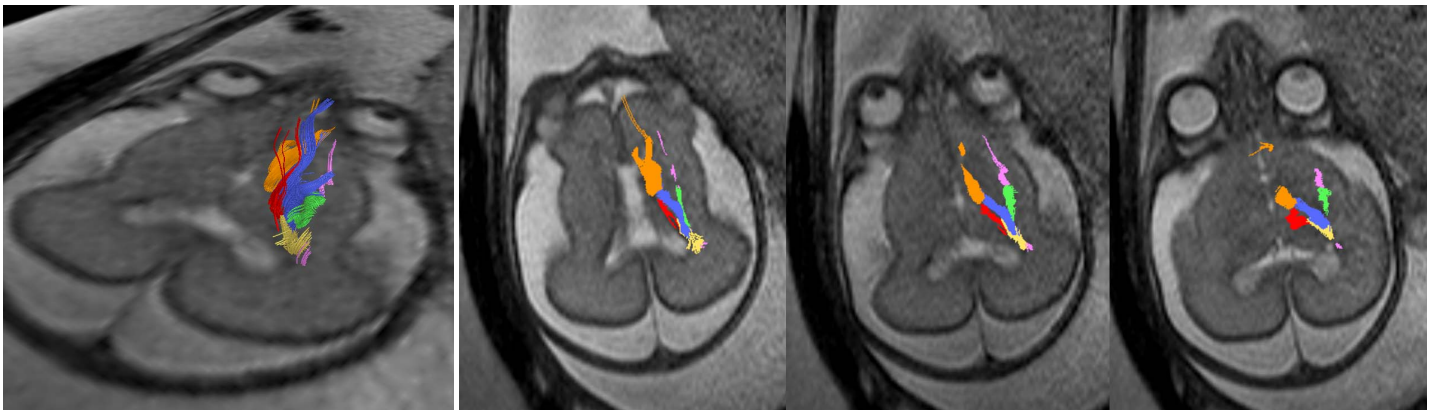

Figure: Left: 3-dimensional visualization of fetal periventricular crossroads at 27 GW. Anterior, superior and posterior thalamic radiation (orange, red and yellow respectively), corticopontine/corticospinal fibers (blue), external capsule fibers (green) and association fibers (pink) are arranged as sagittally oriented strata. Right: 2-dimensional axial tract projection series shows the topographic relations of periventricular crossroad subcomponents. Tractography results are displayed on a coregistered T2-weighted image.

Conclusion:
In utero tractography allows the 3D visualization and non-invasive *in vivo* detection of the main anatomical components of the posterior parietal crossroad region in unsedated fetuses as early as 20 GW. Due to the crucial functional importance of this specific white matter region in the developing fetal brain (Volpe 2009), these results may serve as a basis for a more sensitive detection of acquired and/or malformative brain lesions and may help to further specify their postnatal sensorimotor as well as cognitive outcome.

References:
Judas M, Rados M, Jovanov-Milosevic N, et al. (2005) Structural, immunocytochemical, and MR imaging properties of periventricular crossroads of growing cortical pathways in preterm infants. AJNR Am J Neuroradiol 26, 2671–2684.
Volpe JJ (2009) Brain injury in premature infants: a complex amalgam of destructive and developmental disturbances. Lancet Neurol 8, 110–124.