Diffusion MRI Detects Different Developmental Trajectory in the Thalamus of Adolescents with Attention-Deficit Hyperactivity disorder (ADHD) Compared with Typically Developing Controls

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INTRODUCTION: The thalamus is a major subcortical relay station that mediates communication among brain regions related to memory, consciousness, motor, attention, perception, and the integration of thought processes [1,2]. Since the neuroanatomical basis of attention deficit-hyperactivity disorder (ADHD) is postulated to involve the frontal cortical-basal ganglia-thalamic-cerebellar circuits [3,4], we decided to examine the microstructural integrity of the thalamus in adolescents with ADHD using diffusion MRI, including a new technique called diffusion kurtosis imaging (DKI) [5,6,7,8]. The diffusional kurtosis is of interest as an indicator of the diffusional heterogeneity generated by diffusion barriers, such as cell membranes and organelles, which can indicate the degree of diffusion restriction or tissue complexity.

METHODS: Twenty-one adolescents (age range 12-18 yr) were recruited from the NYU Child Study Center. The ADHD group included twelve adolescents (9 males, 3 females; mean age 15 yr) diagnosed with ADHD according to DSM-IV criteria for Combined Type or Primarily Inattentive type ADHD, and were either drug naïve or off medication on the scan day. The typically developing control group (TDC) included nine adolescents (5 males, 4 females; mean age 14 yr). The protocol was approved by the institutional review board of NYU Langone Medical Center. Written informed consent was received from parental and legal guardians of all subjects. DKI scans were performed on a 3T Siemens Trio MR system, using 30 gradient encoding directions and 6 b-values (0-2500 mm²/µs). Other imaging parameters were: TR/TE=2300/108 ms, FOV=256x256 mm², 15 oblique axial slices, voxel size 2x2x2 mm³ and 2 averages. Anatomical T1-weighted MPRAGE images were acquired with: TR/TE: 2250/2.61 ms, matrix: 226x448x160 and voxel size 0.7x0.6x1 mm³. The DKI dataset was used to calculate parametric maps for the mean diffusivity (MD), fractional anisotropy (FA), axial diffusivity (Dax), radial diffusivity (Dra), mean kurtosis (MK), axial kurtosis (Kax), and radial kurtosis ( Kra) [7,8]. Rectangular regions of interest were drawn on both right and left thalamus on the b=0 images, on three consecutive slices by the same reader (WRG). To assure the same anatomical level in all subjects, the central slice was determined to be at the level of the anterior horns of the lateral ventricles, adding one slice before and one after. To minimize partial volume effect voxels with MD >2 were excluded from the analysis. Group means (+/- s.d) for all diffusion metrics were calculated. Unpaired t-tests were performed to compare groups’ means (p < 0.05) of the diffusion metrics. The relationship between mean diffusion metrics and age was evaluated by Pearson’s correlation (p < 0.05).

RESULTS and DISCUSSION: Group comparison showed no significant mean difference between TDC and ADHD adolescents for all diffusion metrics. The age-related correlation analysis showed a negative correlation for Dax (-0.76; p= 0.017), and a positive age-related correlation analysis showed a negative and ADHD adolescents for all diffusion metrics. The showed no significant mean difference between TDC

Figure 1. Significant (•) age-related correlation was detected for the TDC group for the following indices: Dax: negative correlation (-0.76; p= 0.017); Kax: positive correlation (0.84; p= 0.005). TDC: typically developing control; Dax: axial Diffusivity; Kax: axial kurtosis.

References:


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