Correlation of Brain Diffusion Tensor Imaging Metrics with Cognitive Functions in Patients of Spina Bifida Cystica

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Introduction: Spina bifida Cystica (SBC) is a group of neurodevelopmental defects caused by formation of incomplete neural tube during 5-6 week of gestation with the rate of 0.5-1 per 1000 live birth [1]. Neural tube defect during early pregnancy affects the normal brain development and leads to deficits in cognitive functions and memory. The cerebellar and corpus callosum (CC) abnormalities are parts of the broad spectrum of deficits in neural migrations associated with antenatal development of children with neural tube defect[2]. Diffusion tensor imaging (DTI) is known to provide a deeper understanding of gray and white matter microstructural changes. The changes in DTI metrics provides information about the integrity of the axonal fibers, the coherence with which they are bundled. DTI along with cognitive measures are particularly useful in elucidating the relationships between the integrity of white matter pathways and the efficiency of cognitive and neural processing during brain development[3]. The basal ganglia play a role in diverse functions, ranging from movement control and sensory feedback to set-shifting, attention, visual perception and learning[4]. The CC is associated with motor and cognitive functions. The aim of this study was to look for correlation between DTI derived metrics from the regions of the brain implicated in the cognitive decline in SBC patients.

Material and methods: The present study was performed in 19 SBC patients (13 male, age range 10-22 years) with 21 age/sex matched controls. Informed consent was obtained from patients and controls to conduct the imaging and battery of neuropsychological test (NPT).NPT included number (NCT A & B) and figure (FCT A & B) connection test and subset of modified Wechsler Adult Intelligence Scale (Performance & Children) (WAIS)[5] [picture connection test (PCT), digit-symbol test (DST), picture arrangement test (PAT), object assembly test (OAT) and block design test (BDT)]. Conventional (T2, T1) as well as DT-MRI were performed on a 1.5-Tesla GE MRI system. DTI data were acquired using a single-shot echo-planar dual spin-echo sequence with ramp sampling. The acquisition parameters were: TR=8sec/TE=100ms/number of slice =30-34/slice thickness=3mm/interslice gap=0/FOV=240mm/image matrix=256×256 (following zero-filling)/NEX=8/ diffusion weighting b-factor=1000 s mm-2. The DTI data were processed as described in detail elsewhere[6].The DTI-derived maps were displayed and overlaid on images with different contrasts to facilitate the region-of-interest (ROI) placement.. ROIs were placed in different region of the brain including deep gray matter basal ganglia [caudate nuclei (CN), thalamus (Th) and putamen (P)] and white matter corticospinal tracts (CST), and cingulum (Cing), fornix, genu and splenium (Spl) in SBC patients as well as controls. The size of ROI varied from elliptical to rectangular depending on the size of region The spearman rank correlations between FA, MD and NPT scores were performed in patients and controls.

Result: The abnormal conventional imaging findings were observed in two out of 19 patients. Auqeductul obstruction was observed in one and chiari I malformation along with mild hydrocephalous was observed in other patient. The NPT scores of SBC patients were significantly low as compare to controls (fig.1) Significantly decreased FA values with increased MD values in genu were observed in patients compared to controls. In patient group a significant inverse correlation between FCTB (r=-0.77, p=0.03) scores and FA in genu in patients was observed (fig. 2). A significant inverse correlation was observed between the FA value in CST and PAT (r=-0.73, p=0.00). A siginficant inverse correlation was observed between the FA value in cingulum and NCT B (r=-.79, p=.00). A significant correlation was observed between FA values in CN and FCT B (r=0.865, p=0.05). Significant correlation was observed between MD values and FCT B(r=0.86, p=0.01) and inverse correlation between MD values in spl and FCT B(r=-0.91, p=0.00). A significant correlation was observed between MD values in CST and PAT(r=0.67, p=0.01). A significantly inverse correlation were observed between MD values in CN with NCTA (r=-0.64, p=0.03) & B (r=-0.66, p=0.02) and P with NCT A (r=-0.54, p=0.04) & B (r=-0.61, p=0.02) respectively.

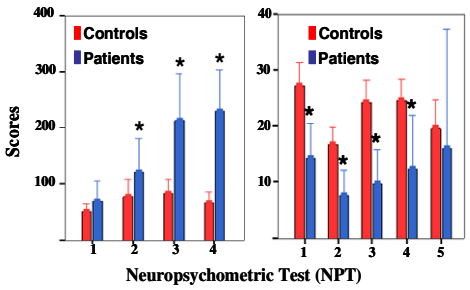

Figure: 1

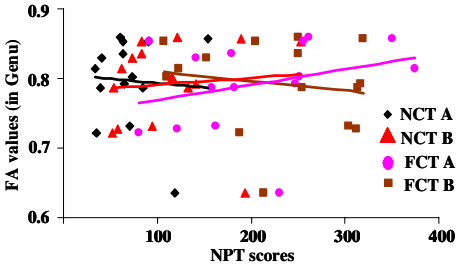

Figure: 2

Figure1: Bars showing scores of various Neuropsychometric tests (NPT) in normals as well as in SBC patients. Number and figure connection test (1=NCT A, 2=NCT B, 3= FCT A and 4= FCT B) and WAIS P (1= PCT, 2=DST, 3=BDT, 4=PAT and 5=OAT) respectively. The Asterisk (*) represent significant difference in NP scores.

Figure2: Showing scatter line fit plot between FA values in Genu with number and figure connection test scores of SBC patients

Discussion: Our results demonstrate that there is a significant relationship between FA, MD and NPT scores in SBC patients. Age-based functional plasticity refers to the hypothesis that functional outcome is better after earlier, compared to latter, brain insult[7]. People have been shown that SBC individuals' exhibits clinical memory, perceptual and motor timing deficits[8].Our observations also demonstrate significant correlation between FA and MD values with FCT score in genu of CC, and significant correlation between FA values in cingulum and NCT B scores which reflects the deficits in learning, memory and timing functions. The FA values in CST are correlated with PAT scores that suggest the deficits in sensory and motor functions. The significantly inverse correlation between MD values and NCT A & B scores in CN and P may reflects the deficits in movement co-ordination and cognitive controls. Based on the present study we conclude that DTI abnormalities significantly correlate with some of the NPT scores in patients.

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