

Understanding Evolution of Neurocysticercosis through Diffusion Tensor imaging

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Introduction: Neurocysticercosis (NCC) is a neurologic infection caused by the larval stage of the tapeworm *Taenia solium*. The infection is endemic in developing countries and increasingly diagnosed in industrialized countries due to tourism and immigration of NCC cases and tapeworm carriers from endemic zones.¹ Parenchymal NCC presents with seizures and headache in 50-80% cases. Besides these two common symptoms, it also produces focal neurological deficit, chronic meningitis, and hydrocephalus.² The symptoms and signs of NCC are non-specific and depend upon the number, topology and stage of the cyst in the brain.³ In the nervous system, the parasite goes through different stages of evolution, which include the following: vesicular, vesicular colloidal, granular nodular and calcified. It is important to identify the different stages of evolution because the stages of cysticerci are kept in mind when treatment options are planned. Magnetic resonance imaging (MRI) has proved useful in the diagnosis of NCC, and appears to be more sensitive than computed tomography (CT) to the pathological stages in the development of the lesion.⁴ A MRI study using magnetization transfer (MT) sequences has shown significant difference in the magnetization transfer ratio calculated from different stages of evolution of cysticercus lesion located in different regions of brain.⁵ Diffusion tensor imaging (DTI), has been shown to be a valuable tool to detect the tissue microstructural changes in various clinical situations. The aim of our study was to investigate the changes in DTI measures during the evolutionary course of NCC lesions from vesicular to calcified stage in the brain.

Materials and Methods: The institutional research ethics committee approved the study. We studied twenty-five patients (16 male and 9 female) aged 16-42 years diagnosed as having NCC on the basis of pathognomonic/major criteria for its diagnosis.⁵ All these patients were suffering from seizures and/or headache. Whole brain conventional MRI (T2, T1, FLAIR and post contrast T1) and DTI were performed on a 3-Tesla GE MRI system. All imaging was performed in the axial plane and had identical geometrical parameters: field of view (FOV) = 240 × 240 mm², slice thickness = 3 mm, interslice gap = 0 and number of slices = 42. DTI data were acquired using a single-shot echo-planar dual spin-echo sequence with ramp sampling with 12 uniformly distributed directions. 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. For the quantification of DTI measures [apparent diffusion coefficient (ADC), fractional anisotropy (FA), linear anisotropy (CL), planar anisotropy (CP) and spherical anisotropy (CS)] ROIs were placed on NCC lesions of all patients.

On the basis of conventional MRI findings the lesions were classified into different stages (vesicular, colloidal, granular nodular and calcified) as described earlier.⁷ The calcified lesion was confirmed on SWAN imaging and CT. An experienced Neuro-radiologist reviewed all the images. Only intracranial parenchymal lesions were evaluated. All images were evaluated with respect to the number of lesions as well as stage of NCC.

Statistical analysis: One-way analysis of variance (ANOVA) with multiple comparisons using Bonferroni, Post Hoc test was performed to evaluate the differences in DTI measures among different stages of NCC. P values of ≤ 0.05 were considered to be significant.

Results: On conventional MR imaging in 25 patients, a total of number of 90 lesions were identified. Single cyst was found in 13/25 patients. On the basis of conventional MRI findings 19/90 cysts were in vesicular stage, 17/90 were in vesicular colloidal stage, 24/90 were in granular nodular stage and 30/90 were in the calcified stage. Successive decrease in ADC and CS values and increase in FA, CL and CP values was observed, moving from vesicular to nodular calcified stage (figure). Among all the DTI measures, significant change was observed only in ADC values while moving from vesicular to nodular calcified stage.

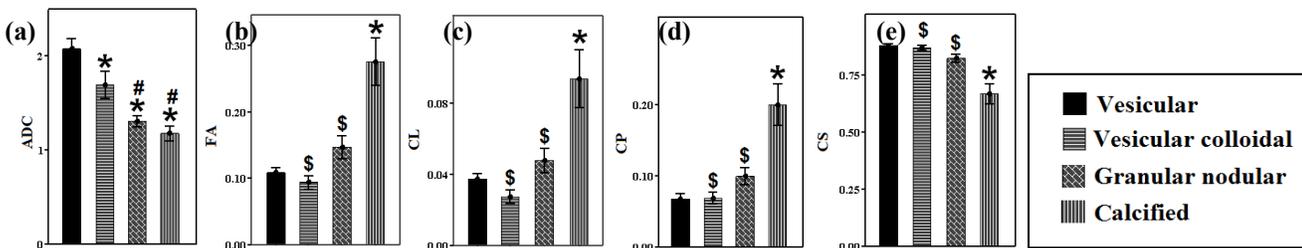


Figure: Plot showing the ADC (a), FA (b), CL (c), CP (d), and CS (e) values of different stages of NCC. * Denotes significant difference between vesicular and other stages; # denotes significant difference of vesicular colloidal with granular nodular and calcified; \$ denotes significant difference of calcified with granular nodular and vesicular colloidal.

Discussion: This study demonstrates the changes in DTI measures during the course of evolution of NCC from vesicular stage to calcified stage in the human brain. DTI has been shown to be useful to study the orientation and tissue integrity of the white matter and other brain lesions. The process of degeneration of NCC involves a continuum that has been categorized by Escobar (1983) in four histopathological stages.⁷ At the vesicular stage, cyst contains clear fluid and the capsule is very thin. Vesicular cyst is followed by vesicular colloidal stage in which due to the host immune response against the parasite the cyst vesicle is filled with proteinaceous fluid and inflammatory cells. In the granular nodular stage early mineralization of the cyst takes place. In the calcified stage, little or no inflammatory reaction can be seen and the residual lesion calcifies.

In this study successive decrease in ADC and CS values and increase in FA, CL, and CP was observed moving from vesicular to calcified stage. ADC and CS values suggest the magnitude of water diffusion, however FA, CL and CP values suggest about the type of anisotropy present in the tissue. Decreased ADC and CS values with degeneration of cyst can be explained on the basis of successive reduction in water content of cyst described in earlier histological studies. On the other hand increased FA, CL, and CP values moving from vesicular to calcified stage suggest transformation of liquid filled vesicle into an organized calcified cyst. Among all of the DTI measures, ADC showed significant decrement with cyst degeneration, suggest that ADC is a better measure for the assessment of NCC stage in these patients. We conclude that DTI measures vary in different stages of evolution of NCC and may be of some value in its characterization. DTI may be used as an additional sequence for staging of the lesions as well as to quantify response to therapy in patients with NCC in future.

References : (1) Garcia HH, et al. *Lancet Neurol* 2005;4:653-661; (2) Monterio L, et al *Acta Neurol Scand* 1995;92:33-40; (3) Takayanagui OM, et al. *Parasitol Int* 2006;55:S111-S115; (4) Chang KH, et al. *AJNR* 1991;12:509-512; (5) Kathuria MK, et al. *JMRI* 1998;8:473-479; (6) Saksena S, et al. *J Gastroenterol Hepatol* 2008;23:e111-e119; (7) Escobar, A. *Cysticercosis of the Central Nervous System*. 1983 Springfield, pp. 27-54.