SWAN imaging substantially increases the Prevalence of hemorrhage in the wall of brain abscess -its implications in Clinical interpretation

R. K. Gupta[1], V. Tomar[1], R. Awasthi[1], V. Bharadwaj[2], B. K. Ojha[2], N. Husain[3], K. N. Prasad[4], R. Venkatesan[5], and R. K. Rathore[6]

[1]Radiodiagnosis, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, India, Lucknow, Uttar Pradesh, India, [2]Neurosurgery, Chatrapati Sahu ji Maharaj Medical University, Lucknow, Uttar Pradesh, India, [3]Pathology, Chatrapati Sahu ji Maharaj Medical University, Lucknow, Uttar Pradesh, India, [4]Microbiology, Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, India, Lucknow, Uttar Pradesh, India, [5]Wipro-GE Healthcare, Bangalore, Karnataka, India, [6]Mathematics & Statistics, Indian Institute of Technology, Kanpur, Kanpur, Uttar Pradesh, India

Introduction: The presence of hemorrhage in brain abscess is rare and there are isolated case-reports that have described it on MRI. Demonstration of hemorrhage on CT and/or MRI in a lesion is usually interpreted as neoplasm. With the advent of susceptibility imaging it has become possible to demonstrate even microhemorrhages which may lead to misinterpretation and inappropriate management of some of the benign intracranial lesions[1]. Earlier studies have shown neo-angiogenesis with increased intracranial pressure as the possible reason of hemorrhage in some of the benign lesions like brain abscess[2]. Diffusion tensor imaging (DTI) has been used in the diagnosis and management of the brain abscess as fractional anisotropy (FA) is shown to be correlated with neuroinflammatory cytokines which get downregulated following therapy. DTI has also been studied in different stages of hemorrhage and hemorrhagic lesions and is known to be high in even tumors with chronic hemorrhage. FA is reported to be higher in the wall of the abscess than the cavity and is considered to be due to the combination of presence of inflammatory cells and structural configuration of the fibroblast. In the present study, we wanted to understand the real prevalence of hemorrhage in the abscess using T2 star weighted angiography (SWAN) imaging and to study the influence of this hemorrhage on DTI metrics like FA, apparent diffusion coefficient (MD), linear anisotropy (CL), planer anisotropy (CP) and spherical anisotropy (CS).

Materials and methods

***Subjects*:** Twenty six patients with a diagnosis of intracranial abscess underwent MRI. The diagnosis was confirmed after surgical intervention (resection or aspiration) followed by culture and histology of aspirated pus and abscess wall respectively.

***Data acquisition*:** All the patients underwent conventional MRI on a 3T MR scanner (Signa Hdxt, General electric, Milwaukee, USA), using a 12 channel head coil after the approval from the institutional ethics committee. Both the conventional MRI and DTI was performed in the axial plane and had identical geometrical parameters: field of view (FOV) = 240 × 240 mm^2, 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. In addition, SWAN sequence with TR/TE/Flip Angle/slice thickness: 47/25/15/2.4mm and acquisition matrix of 320x224 was also performed for the demonstration of possible hemorrhage in and around the abscess wall. The DTI data was processed as described in detail elsewhere[3]. The DTI maps were registered, displayed and overlaid on images with different contrasts to facilitate the region-of-interest (ROI) placement. For the quantification of DTI (MD, FA, CL, CP and CS) measures, regions of interest were placed on abscess wall of all patients. All statistical analysis was performed by using SPSS, version 16.0 (SPSS, Chicago, IL, USA).

Histopathology*:* The excised abscess walls were stained for the Prussian blue staining to look for the histological evidence of hemorrhage.

***Statistical analysis*:** Independent samples T-test was performed to look whether any of the DTI metrics and/or MTR values were significantly different between hemorrhagic and non-hemorrhagic abscess wall or not.

Results: Out of 26, 15 underwent surgical removal of the lesion. Eleven of these patients were found to be positive on Prussian blue staining while 4 showed negative results. On SWAN imaging, 13/26 patients demonstrated hemorrhage (Fig.1). On independent sample T-test, FA ($p<0.001$) and CL ($p<0.001$) values were found to be significantly higher while CS (($p<0.001$) was significantly lower in hemorrhagic abscess walls as compared to non-hemorrhagic ones (Fig. 2). None of the other parameters were significantly different in hemorrhagic as compared to non-hemorrhagic abscess walls.

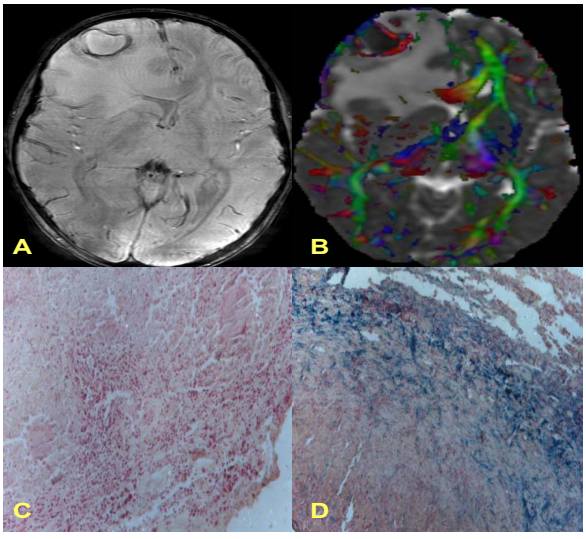

Fig.1:Showing demonstration of hemorrhage in a patient with intracranial abscess on A) SWAN, B) RGB-FA overlaid on MD MAP C) Negative&D) Positive Prussion blue staining of abscess wall

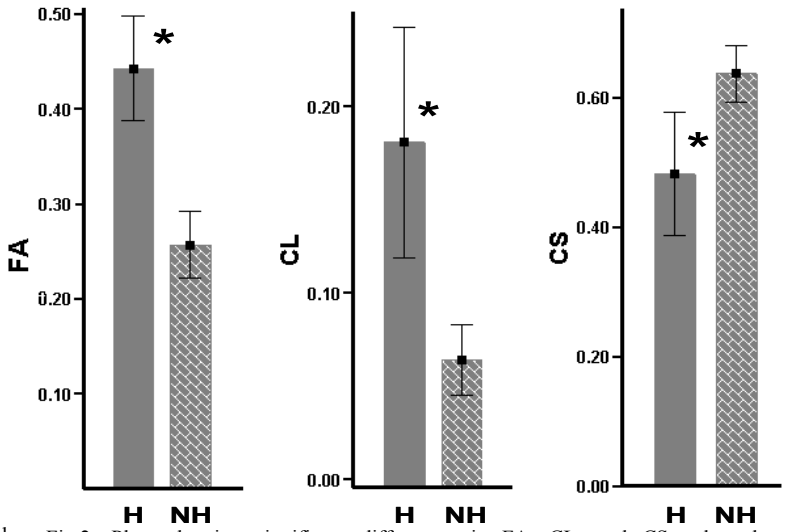

Fig.2: Plots showing significant differences in FA, CL, and CS values between hemorrhagic (H) and non-hemorrhagic (NH) abscess wall.

Discussion: We observed hemorrhage in the wall of abscess in 73% of the abscess wall that was verified on histopathology. This is in contradiction to the earlier isolated case reports where it has been considered rare[4]. It appears that SWAN has improved the demonstration of the hemorrhage that is due to the increased neoangiogenesis in the wall of the abscess. The newly formed blood vessels are fragile and prone to be ruptured. An increase in intracranial pressure due to increasing size of the abscess cavity put a trigger on the rupture. We have found increased FA in abscess wall with hemorrhage as confirmed on histology. High FA values have been reported in a number of pathological conditions with reasons such as increased cell density as well as chronic hemorrhage in tumors or due to accumulation of adhesion molecules in brain abscess cavity[5]. It has been reported that presence of iron in the tumor tissue influences the DTI metrics. The presence of intracellular iron causes increased anisotropy by introducing local field gradients[6]. We conclude that hemorrhage is a common feature and does not always indicate neoplasm. The presence of intracellular iron in addition to concentrically laid collagen fibers may have synergistic effect on FA and CL in brain abscess.

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