# ADC with higher b-value correlate better with viable cell count quantified from the cavity of the brain abscess

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**Introduction:** Brain abscess (BA) is a focal suppurative process within the brain parenchyma. The abscess cavity contains inflammatory cells with intact cell membranes and nuclei, necrotic tissue debris, proteinaceous exudates, bacterial metabolites, cytosolic amino acids, with or without its causative organism (1).The abscess cavity shows high signal on diffusion-weighted imaging (DWI) with low apparent diffusion coefficient (ADC) (2). ADC in brain abscesses is mainly influenced by the density of viable inflammatory cells present in the pus, irrespective of the etiology of the abscess (2). In the BA, Gupta et al have reported that the aggregation of inflammatory molecules is responsible for high FA in the abscess cavity (1). The aggregation of intact inflammatory cells in the abscess cavity gives the appearance of pseudofibers which increases the diffusion anisotropy (1). It has been reported that high cellularity is responsible for low ADC value in brain tumor (3). Recently few studies have shown the utility of high b-value in diagnosis of various diseases conditions (4,5). Theoretically, higher b-value DWI provides better contrast with its reflection of more tissue diffusivity and less T2 shine through effect (6). However, at 1.5T or lower field strength, higher b-values are not usually used in clinical practice due to inferior signal-to-noise ratio (SNR) (7). High b-value DWI (b=3000 s/mm$^2$) has been shown to predict improvement in the grading of cerebral glioma at 3T (4). The purpose of this study was design to evaluate the mean ADC from different b value in the abscess cavity with an aim to see which b-value better correlates with the viable cell counts.

**Materials and Methods:** Fifteen patients [nine males and six females (mean age = 26 year)] with brain abscess underwent conventional MRI (T2, T1-weighted) and DWI on a 3T MR scanner (Signa Hdxt, General electric, Milwaukee, USA), using a 12 channel head coil. DWI parameters were: TE=87.4ms/TR=6500ms/NEX=2.0/no. of slice=42/slice thickness=3mm/FOV=240mm/image matrix=256x256) was performed with b-values 1000 s/mm$^2$, 2000 s/mm$^2$ and 3000 s/mm$^2$. DWI data was processed and ADC values were calculated by placing elliptical or circular ROIs (40-60mm$^2$) inside the abscess cavity in all slices (5-8) where lesion was apparent. The ADC values quantified in different slices of the abscess cavity was pooled together to get mean ADC of the each abscess cavity from each patients. The pus was collected in sterilized vial and snap frozen in liquid nitrogen immediately after surgery/aspiration. At the same time 1-2 ml of aspirated pus inoculated into BACTEC plus aerobic/anaerobic media (Becton Dickinson Co., Sparks, MD, USA) to isolate the aerobic, facultative anaerobic and anaerobic bacteria for the diagnosis of etiologic agents. On culture 11 were found to be pyogenic, one fungal, one nocardia, and two were confirmed as tubercular. Cell counts were performed in a hemocytometer (Burker-Turk, Japan) [after diluting pus 100 to 1000-fold in white blood cell (WBC) diluting solution] and expressed as cells/mm3. We calculated total number of viable cells per unit area in the abscess cavity by dividing total number of viable cells with area of the abscess cavity. Bivariate analysis of correlation was performed to study the relationship between mean ADC values and viable cell counts from the abscess cavity. All statistical analysis was performed by using SPSS, version 16.0 (SPSS, Chicago, IL, USA).

**Results:** In the abscess cavity, the viable cell count varied from 6000-11000 cells per unit area. The mean ADC values (0.00059 s/mm$^2$, 0.00048 s/mm$^2$, and 0.00039 s/mm$^2$) were quantified from abscess cavity at different b-values (b=1000 s/mm$^2$, b=2000 s/mm$^2$, and b=3000 s/mm$^2$) respectively. We found that as the b-value increases, mean ADC value decreases. A significant negative correlation was observed between cell counts and ADC values at b=1000 s/mm$^2$, b=2000 s/mm$^2$ and b=3000 s/mm$^2$ [(r = - 0.82, p = 0.01), (r = - 0.84, p = 0.01), and (r = - 0.98, p = 0.01)] respectively (Figure 1A-D).

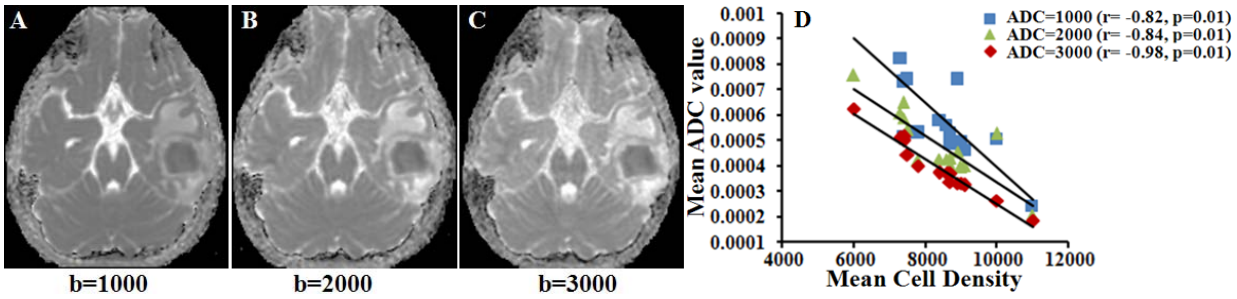


**Figure 1:** A 26 year old male shows ADC maps (A-C) brain abscess at left temporal lobe at b-value 1000, 2000 and 3000 s/mm$^2$. Scattered plot (D) shows the correlation of mean ADC values at different b values with mean viable cell counts.

**Discussion:** Significant negative correlation was observed between viable cell counts and mean ADC values measured from all b values (1000 s/mm$^2$, 2000 s/mm$^2$, and 3000 s/mm$^2$). However, at b=3000 s/mm$^2$ we got a near to perfect negative correlation between mean ADC and viable cell counts. It has been shown in *in-vivo* and *ex-vivo* experiment that the increase in cell density negatively correlates with mean ADC values (2). The mean ADC values measured from abscess cavity showed similar trends to those exhibited by cellular tumors in humans (3) and animal tumor models (8). Previously it has been shown that the BA is usually associated with high signal intensity on diffusion weighted imaging (DWI) with decrease in ADC values (2). The viable inflammatory cells in the abscess cavity are responsible for increase diffusion anisotropy in BA (1) and these inflammatory cells are used as a marker for the treatment of BA (1). It has been shown *in-vitro* that the diffusion of water molecules in the intracellular space is lower than the extracellular space. Mardor et al has used b=4000 s/mm$^2$ to amplify the sensitivity of water diffusion properties and enable the separation of signals arising from intracellular to extra cellular water diffusion (5). Hence, DWI at high b-value may be more sensitive to several physiological and morphological characteristics of the tissues, which are associated with the diffusion of the low and high-mobility of water molecules (5). It has been reported that mean ADC decreases as the extra cellular volume decreases (9). The high b value picks more viable cells in the abscess cavity due to the separation of water molecules in the intracellular to extracellular environment.

We conclude that the viability of cells in the abscess cavity represents the activity of diseases. In BA we should use b=3000 s/mm$^2$ to know the activity of the diseases in the abscess cavity for the assessment of disease in response to therapy.

**References: 1)** Gupta et al. *AJNR Am.J.Neuroradiol*. 2008; 29 (2):326-332. **2)** Mishra et al. *Magn. Reson. Med*. 2005 ;54:878-885**. 3)** Gupta et al. *J Neurooncol*. 2000; 50: 215-226**. 4)** Seo et al. *AJNR. 2008;29:458-463*.**5)**Mardor et al. *Neoplasia*. 2004 ;6 :136-142.**6)** *DeLano* et al. *AJNR Am J Neuroradiol*. 2000;21:1830–1836..**7)** *Kim et al. AJNR Am J Neuroradiol. 2005;26:1487–149*. **8)** Lyng et al. *Magn. Reson. Med*. 2000;43:828–836. **9)** Anderson et al. *Magn Reson Med*.1996;35:162–167.