

PROPER DIFFUSION-WEIGHTED WINDOW LEVEL IN MR IMAGING IN ACUTE VIRAL ENCEPHALITIS AND HYPOXIC ISCHAEMIC ENCEPHALOPATHY

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Abstract

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Introduction: Diffusion-weighted magnetic resonance (MR) imaging provides image contrast that is different from that provided by conventional MR techniques. Improper Diffusion weighted (DW) window level obscures the diffuse cortical abnormality on DW image, hence proper windowed Diffusion weighted images are must for evaluation of cortical & deep grey matter nuclei abnormality. The increased sensitivity of DWI sequences with regard to viral encephalitis/hypoxic ischaemic encephalopathy (HIE) has been shown in several studies This study was performed to evaluate the role of proper DWI window level (250/150) in the diagnosis of viral encephalitis & HIE vs improperly windowed (500-850/250-400) DW images for evaluation of cortical & deep grey matter nuclei.

Material and Methods: We performed conventional MRI including T1, T2-Weighted and fluid attenuated inversion recovery (FLAIR) sequences and DWI in 16 patients with viral encephalitis & 02 patients of hypoxic ischaemic encephalopathy diagnosed on the basis of laboratory, clinical and radiologic findings. Gradient B value of diffusion was 0, 400 & 800. Properly windowed (250/150) DW image versus an improperly windowed (500-850/250-400) DW image were evaluated for evaluation of cortical & deep grey matter nuclei signal intensity.

Results: Axial DW images were reviewed at a consistent window level of 250/150. DW image with proper window level of 250/150 shows that the cortical/ deep gray matter nuclei abnormality is more evident. Apparent diffusion coefficient (ADC) map further illustrates the cortical restricted diffusion. Although with improperly windowed DWI (500-850/250-400), there is accentuated grey-white matter differentiation, but improper window level obscures the diffuse cortical abnormality on DW image. With proper window level of DW images, diffusion restriction was picked up in all the 16 cases of acute viral encephalitis and 02 patients of HIE.

Conclusion: Proper window level of DWI (250/150) is helpful in early diagnosis of acute viral encephalitis & hypoxic ischaemic encephalopathy.

Keywords: Diffusion-Weighted Window Level, Acute Viral Encephalitis. Hypoxic ischaemic encephalopathy

INTRODUCTION

Diffusion MRI (or dMRI) is a MRI method which came into existence in the mid-1980s.¹ It provides image contrast that is dependent on the molecular motion of water, which may be substantially altered by early disease process. DW MR imaging uses fast (echo-planar) imaging technology, and imaging time ranges from a few seconds to 2 minutes.²

DW imaging images the random motion of water molecules as they diffuse through the extra-cellular space, regions of high mobility means “rapid diffusion” and appears dark on DWI & regions of low mobility means “slow or restricted

diffusion” & appears bright in DW images.³ (Figure-1) Free water experiences the strongest signal attenuation at higher b-values and appears dark. The b-value is a factor of diffusion weighted sequences. The b factor summarizes the influence of the gradients on the diffusion weighted images. The higher the value b, the stronger the diffusion weighting. The b-value identifies the measurement’s sensitivity to diffusion and determines the strength and duration of the diffusion gradients. It is measured in s/mm². (b= 400 sec/mm², b = 1,000 sec/mm²; effective gradient etc).⁴

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DW Images	Increased diffusion → greater signal attenuation → lower signal intensity → dark area
	Reduced diffusion → smaller signal attenuation → higher signal intensity → bright area
ADC Maps	Increased diffusion → smaller signal attenuation → higher signal intensity → bright area
	Reduced diffusion → greater signal attenuation → lower signal intensity → dark area



Fig.-1: Regions of high mobility “rapid diffusion” - bright on B0, dark on B1000 and bright on ADC

Apparent diffusion coefficient (ADC) is a measure of the strength (velocity) of diffusion in tissue. The rapid the diffusion, the greater the diffusion coefficient, i.e. high ADC value. If diffusion is slow (restriction), the lower the ADC value. When measuring molecular motion with DW imaging, only the ADC can be calculated. Apparent diffusion coefficient (ADC) is a measure of the magnitude of diffusion (of water molecules) within tissue. An ADC of a tissue is expressed in units of mm^2/s . There is no unanimity regarding the boundaries of the range of normal diffusion, but ADC values less than 1.0 to $1.1 \times 10^{-3} \text{ mm}^2/\text{s}$ (or 1000 - $1100 \times 10^{-6} \text{ mm}^2/\text{s}$) are generally acknowledged in adults as indicating restriction, however this is entirely dependent on the organ being imaged and the pathology.⁵

Some rough useful values ($10^{-6} \text{ mm}^2/\text{s}$) are: white matter: 670 – 800, cortical grey matter: 800–1000, deep grey matter: 700 – 850 and CSF: 3000 – 3400.⁶

The contrast between grey and white matter seen on the DW image is due to T2-weighted contrast. This residual T2 component on the DW image makes it important to view the ADC map in conjunction with the DW image.⁷ In lesions such as acute viral encephalitis, acute hypoxic ischaemic encephalopathy or acute stroke, the T2-weighted and DW effects both cause increased signal intensity on the DW image. DWI due to its detection of restricted motion of water molecule shows early bright signal than T2WI. Therefore, we have found that we identify regions of early disease as decreased diffusion best on DW images. ADC

maps are used to exclude “T2 shine through” as the cause of increased signal intensity on DW images. ADC map are useful for detecting areas of increased diffusion that may be masked by T2 effects on the DW image. Therefore DWI should always be interpreted with ADC or exponential images.⁸

It is mandatory to view DWI at a proper window level, although with improperly windowed DWI (500-850/250-400), there is accentuated grey–white matter differentiation, improper window level obscures the diffuse cortical abnormality on DW image. The abnormality is more distinct on this properly windowed DW image (windowed at 250/150).⁹

MATERIAL & METHODS

The study was conducted by using a 3-Tesla system (Vario, Siemens,) with echo-planar capability. We performed conventional magnetic resonance imaging (MRI) including T1, T2-Weighted and fluid attenuated inversion recovery (FLAIR) sequences and DWI in 16 patients with viral encephalitis & 02 patients of hypoxic ischaemic encephalopathy diagnosed on the basis of laboratory, clinical and radiologic findings.

Gradient B value for diffusion imaging was 0, 400 & 800. Properly windowed (250/150) DW images versus improperly windowed (500-850/250-400) DW axial images were evaluated for evaluation of cortical & deep grey matter nuclei signal abnormality.

RESULTS

Axial DW images were reviewed at a consistent window level of 250/150 in all the patients. DW image with proper window level of 250/150 shows that the cortical/ deep grey matter nuclei abnormality is more evident and Apparent diffusion coefficient (ADC) map further illustrates the cortical restricted diffusion.

Although with improperly windowed DWI (500-850/250-400), there is accentuated grey–white matter differentiation, improper window level obscures the diffuse cortical abnormality on DW image. With proper window level (250/150) of DW images, diffusion restriction was picked up in all the 16 cases of acute viral encephalitis and 02 patients of HIE. The DW images were improperly windowed at 500-850/250-400 by the technologist; these

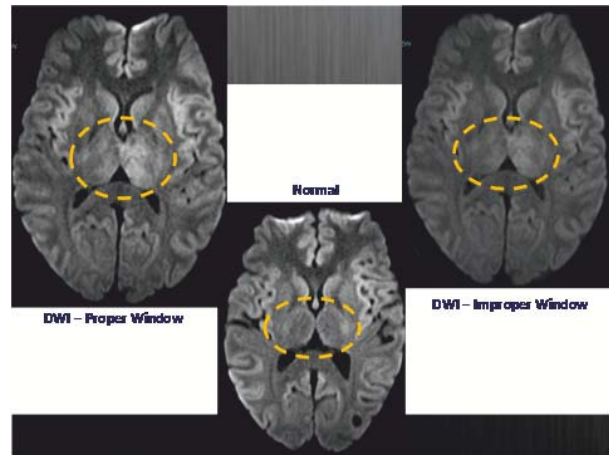


Fig 2b: Same patient of Fig 2a, same age group of normal patient with proper DWI window (250/150) compared with patient with viral encephalitis with proper(250/150) & improper (450/200) window/level. Abnormality was detected easily with proper window /level & was obscured with improper window/level.

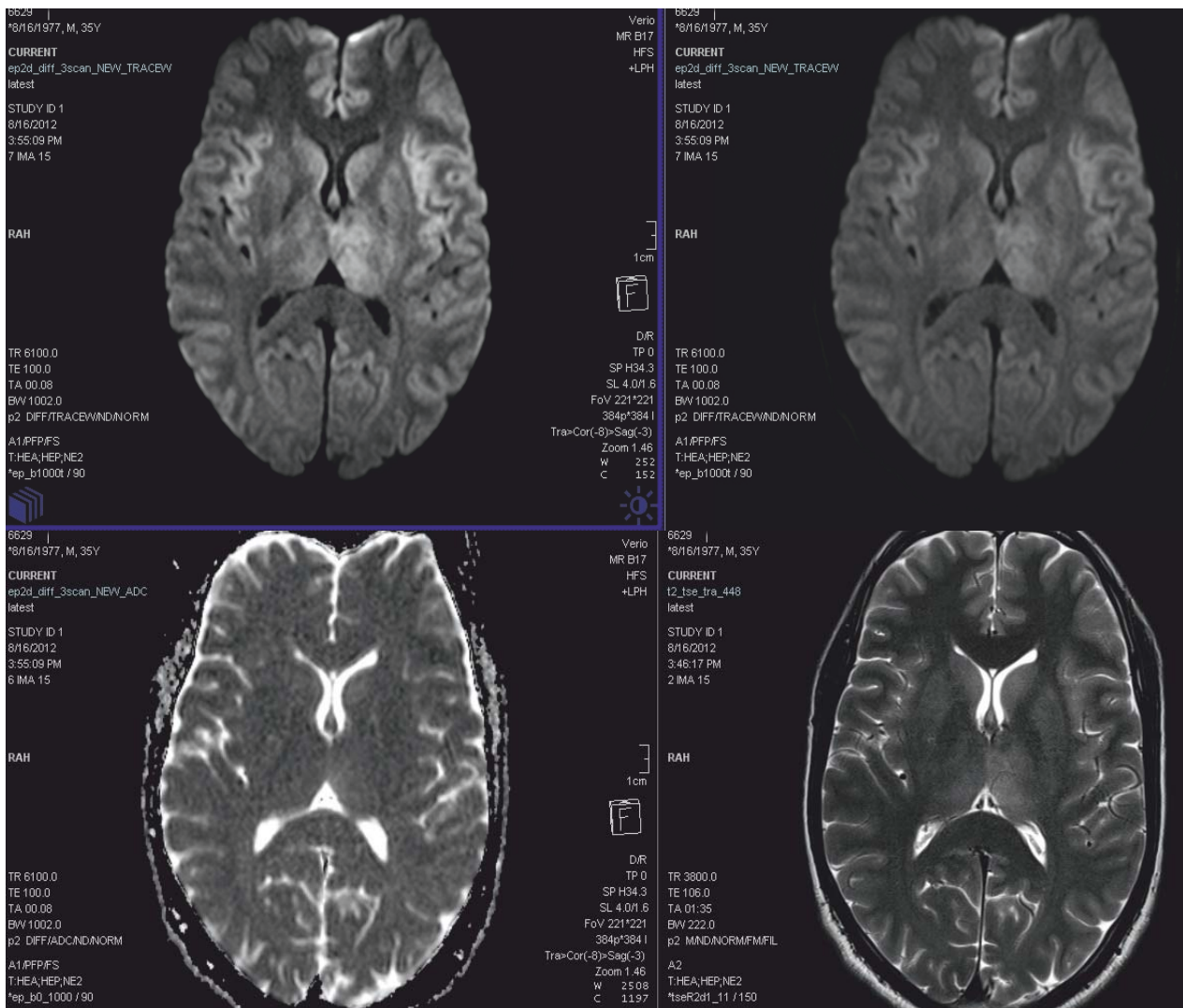


Fig 2a: 35 yrs patient viral encephalitis MRI done at 5th day With proper window/level(250/150) cortical/ deep grey matter abnormality is still easily visible, which is obscured with improper window/level(450/200). ADC shows relatively increased value . Abnormality is now visible on T2WI also

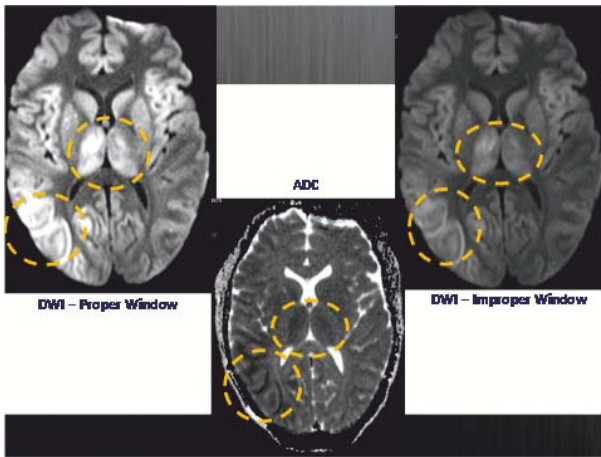


Fig 3: Viral encephalitis: Regions of low mobility “slow diffusion” are bright. The abnormality is more distinct on this properly windowed DW image (windowed at 250/150), which shows diffuse uniform cortical and thalamic hyperintensity with accentuation of the grey–white matter interface, ADC map demonstrates severe, restricted diffusion .

images appeared deceptively symmetric without focal hyperintense abnormality.

A patient of encephalitis was imaged on 5th day still showed DWI hyperintensity with proper window (Fig-2a & b) which was difficult to appreciate with improper window (450/200). Patients images within 5 days showed striking cortical, basal ganglion & thalamic hyperintensity with accentuation of the grey–white matter interface (Fig 3 & 4).

A 72 yr old patient had an anoxic episode during surgery and underwent cardiopulmonary resuscitation. At MR imaging (obtained at 24 hrs after), the T2-weighted and FLAIR images, respectively) appeared normal. Initially, the DW images were improperly windowed at 600/250 (Fig 5a) by the technologist and sent to the radiologist for review; these images appeared deceptively symmetric without focal hyperintense abnormality. However, the

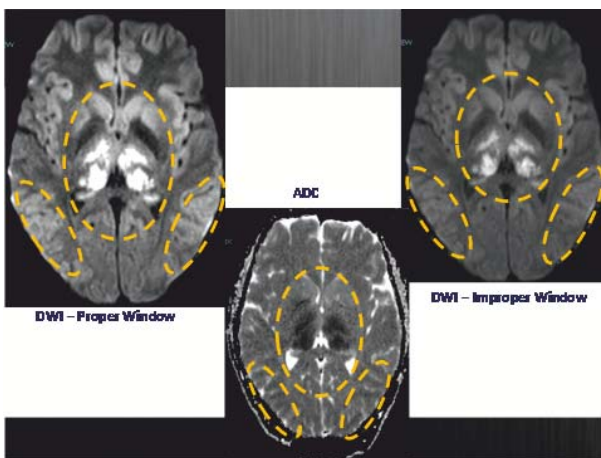


Fig 4: Viral encephalitis: DW image with initial window/level (improper window/level of 850/400) that is not in keeping with our usual window/level (250/150) shows that the diffuse cortical abnormality is obscured which is pronounced with proper window.

images were windowed again at a window/level of 250/150 (Fig5b); these properly windowed DW images demonstrated diffusely abnormal hyperintense cortical signal that was shown to be restricted on the ADC map.

In a 18 yr old boy with history of strangulation the DWI with proper window(250/150) revealed striking diffuse cortical , basal ganglion & thalamic hyperintensity with low

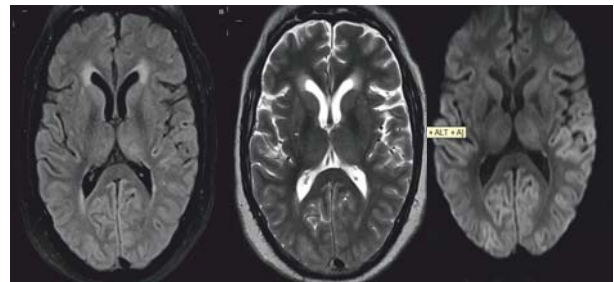


Fig 5a: A 72 yrs male with cardiogenic shock, revived, Hypoxic ischaemic encephalopathy, Flair, T2 and & DWI Improper window 600/250, The abnormality is obscured.

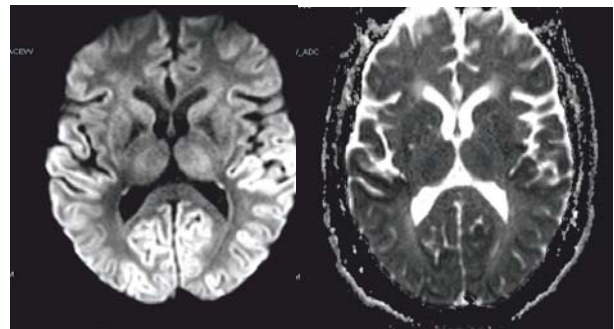


Fig 5b: In same 72 yrs male with Hypoxic ischaemic encephalopathy, DWI with proper window 250/150, The cortical ,basal ganglion and thalamic abnormality is easily revealed with low ADC.

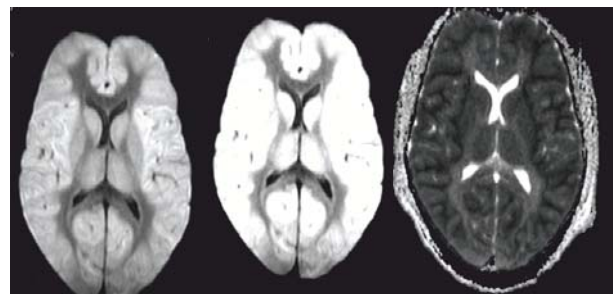


Fig 6: 18yrs boy with history of strangulation, DWI with improper window(400/200) and DWI with proper window(250/150) and ADC. With proper window Gyri are strikingly bright & ADC is low suggestive of severity of HIE.

ADC suggestive of severity of cytotoxic gyral edema in hypoxic ischaemic encephalopathy (Fig 6).

DISCUSSION

A typical MRI protocol consisted of routine T1 and T2 spin-echo sequences and a fluid-attenuation inversion recovery (FLAIR) sequence and DWI.

Diffusion-weighted imaging (DWI) is now increasingly used. The increased sensitivity of DWI sequences with regard to viral encephalitis/HIE has been shown in several studies.¹⁰ In our study, initially, the DW images were improperly windowed at 500-850/250-400 by the technologist; these images appeared deceptively symmetric without focal hyperintense abnormality. However, the images were windowed again at a window level of 250/150; these properly windowed DW images demonstrated diffusely abnormal hyperintense cortical / deep grey matter nuclei signal that was shown to be restricted on the ADC map. Conceptually, the imaging appearance is much more visually apparent on properly windowed DW images. Hence, the brain can appear deceptively normal to the unaware observer on improperly windowed DW images.¹¹ The key to correct interpretation of the abnormal area is proper windowing on DW images.

The MR appearance using DWI is closely related to pathologic changes that occur following viral invasion. In the acute stage, there are areas of congestion, lymphocytic perivascular cuffing and pathological thrombus formation. These areas might be responsible for the cytotoxic edema that leads to restricted diffusion and low apparent diffusion coefficient (ADC). In the late acute and early sub acute stages, the components of vasculitis and perivascular cuffing diminish. Therefore, the proportion of diffusion restriction decreases and ADC starts to increase. DWI has been reported to be more sensitive than T1- and T2-weighted images for detecting and predicting extent of HIE also, because of decreased intracellular transport, influx of water into intracellular space, and decreased brain pulsatility. However, the restricted diffusion is only seen for a few days after the onset of symptoms. If imaged later than 5 days after the anoxic insult, after which “pseudo normalization” of the ADC values may occur, and high signal intensity may not be seen within the cortex on DW images.¹²

CONCLUSION

Proper window level of DWI (250/150) is helpful in early diagnosis of acute viral encephalitis & hypoxic ischaemic encephalopathy. It effectively detects and depicts the border of infected /involved areas more precisely. Thus, we should consider that the proper windowing of DWI sequence in viral encephalitis and hypoxic ischaemic encephalopathy is mandatory, as it detects early encephalitic lesions .However, the diffusion images should always be correlated and viewed along with ADC images.

Furthermore, initial DWI and ADC map imaging could predict outcome in some patients.

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