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Apparent diffusion coefficient and diffusion-weighted signal intensity of the interpeduncle region of the midbrain in adults: initial evaluation☆

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ABSTRACT

Objective: The diffusion-weighted signal intensity (SI) of the interpeduncle region (IPR) of the midbrain has not been fully understood. This study was to evaluate the apparent diffusion coefficient (ADC) and SI of the IPR on axial diffusion-weighted imaging (DWI). **Methods:** Axial brain DWI (4-mm slice thickness, no gap) was performed in 145 healthy subjects at 1.5T MR scanner. Correlations between the contrast-to-noise ratio (CNR) and ADC value in the IPR and age, gender were statistically analyzed. **Results:** The CNR was significantly higher in the IPR than in the periaqueductal gray (PAG) (P<.001). The CNR of the IPR positively correlated with age (P=.032) but not with gender (P=.091). The ADC value was significantly lower in the IPR than in the PAG (P<.001). The ADC value of the IPR did not correlate with age (P=.522) or gender (P=.217). There was no correlation between the CNR and ADC value of the IPR (P=.622). **Conclusions:** The IPR usually shows high SI on DWI in healthy subjects, especially in older adults. DWI combined with the ADC maps would help to evaluate signal characteristics of the IPR.

1. Introduction

Diffusion-weighted imaging (DWI) has been proved to be a robust technique for the evaluation of a variety of neurologic diseases, such as hyperacute stroke [1–3], epilepsy [4], Alzheimer disease [5], multiple sclerosis [6–9], and Parkinson disease [10]. However, there are many regions of physiological hyperintensity on DWI of brain, for example, the cingulate gyrus and insula [11]. These signal intensity (SI) findings are not abnormal signs.

In clinical practice, we have often encountered a high SI of the interpeduncle region (IPR) of midbrain from neurologically healthy adults on axial DWI—this would need to be mentioned and evaluated, as it would be much more useful to identify areas of abnormal diffusion optimally. To recognize abnormally increased SI in the IPR on DWI, the present study is to (a) describe qualitatively and quantitatively the signal characteristics of the IPR on axial DWI in neurologically healthy adults; (b) evaluate the effects of age and gender on the SI of the IPR; and (c) assess the correlation between apparent diffusion coefficient (ADC) value and age, gender, and contrast-to-noise ratio (CNR) of the IPR.

2. Materials and methods

The institutional review board approved this retrospective study with waived informed consent.

2.1. Patient population

This retrospective study included 145 neurologically healthy subjects (70 males, 75 females; age range: 31–79 years; mean age: 48.7 years). The recruited criteria for study selection were normal findings at neurologic examination, no history of neurological disease, malignancy, stroke or brain surgery, and normal results brain magnetic resonance imaging. Indications for MR examination included headache (n=68), dizziness (n=45), and paresthesia (n=32).

2.2. Imaging procedures

MR examinations were performed with a 1.5T superconducting system (Siemens Medical Systems, Avanto, Germany) with an eight-channel head coil.

The MR imaging protocols were as follows: T1-fluid attenuation inversion recovery (FLAIR) (repetition time (TR)/echo time (TE)/inversion time (TI)=2000/55/680 ms, one signal averaged, matrix=256×256), T2-weighted fast spin-echo. (TR/TE=4000/99 ms, one signal averaged, matrix=256×256), turbo FLAIR (TR/TE/TI=9000/99/2500 ms, one signal averaged, matrix=256×256), and DWI (three-

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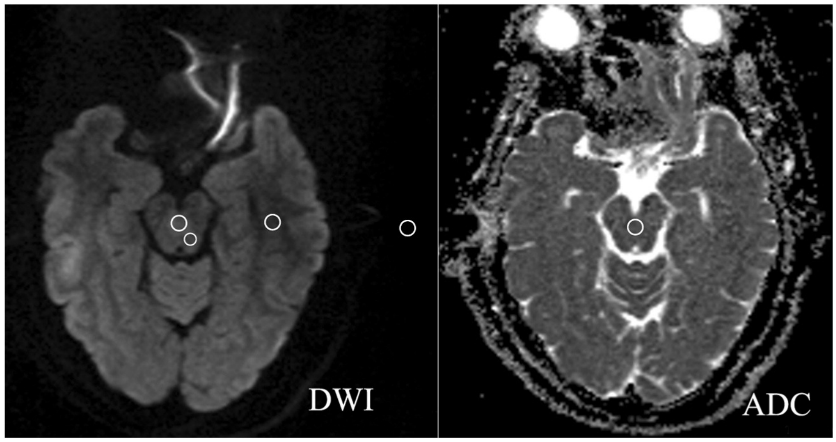

Fig. 1. Axial DWI (TR/TE=3200/94 ms, b=1000 s/mm^2, phase encoding direction with right to left) shows the positioning of ROIs in air, the TLWM, PAG, and IPR of the midbrain, respectively. Axial ADC map displays the positioning of ROI in IPR.

directional single-shot echo-planar imaging protocol, TR/TE=3200/94 ms, four signals averaged, b=0 and 1000 s/mm^2, matrix=192×192) with parallel imaging (GeneRalized Auto-calibrating Partially Parallel Acquisition, GRAPPA). All routine sequences were performed on axial plane using identical parameters for number of slices, field of view (230 mm), phase encoding direction (right to left), slice thickness (4 mm), and no intersection gap. Axial DWI (b=1000 s/mm^2) and ADC map were used for quantitative analysis.

2.3. Image evaluation

2.3.1. Qualitative evaluation

The IPR was identified at the ventral and inferior level of the midbrain, the rear of the interpeduncular fossa, the front of the periaqueductal gray (PAG) of midbrain.

SI of the IPR was graded with a three-point scoring system: hypointense (Grade 1), isointense (Grade 2), and hyperintense (Grade 3) to the PAG of midbrain. The evaluation was conducted by two neuroradiologists (25 years and 22 years of experiences, respectively) independently. They were blind to each other and to the clinical information. Discrepancies of SI grading were resolved by consensus.

SI of the PAG was compared with that of the IPR because the IPR and PAG are well depicted on the same section on the axial DWI.

2.3.2. Quantitative evaluation

Region of interest (ROI) was performed on axial DWI and ADC map by a single investigator (neuroradiologist, 22 years of experiences), who was blind to the clinical information. For quantitative interpretation, assessment of the SIs was done by placing circular ROIs in the IPR and the background of the images (Fig. 1). Circular ROIs with an optimal size (IPR: 20–25 pixels; PAG: 10–15 pixels) were hand placed on axial DWI.

Background signal was measured in the temporal lobe white matter (TLWM) on the same image. Noise was defined as the standard deviation (S.D.) of the SI within an ROI outside the head (i.e., air).

To measure the CNR, we used the formula CNR=[SI(IPR)−SI(b)]/S.D. (noise), where SI(IPR) is the SI of the IPR and PAG, SI (b) the SI of the background and S.D. (noise) the S.D. of the SI of air. Therefore, the CNR of IPR to background and PAG to background were calculated.

The ADC value of the IPR was also measured on axial ADC map (Fig. 1). The size of circular ROI in the IPR on the ADC map was copied from the corresponding DWI.

2.4. Statistical analysis

The CNR and ADC value were compared between the IPR and the PAG by the paired-samples *t* test. One-way analysis of variance was used to evaluate the difference of the CNR and ADC value of IPR between males and females. Stepwise regression analysis was used to evaluate the effect of age on CNR and ADC value of the IPR and the correlation between CNR and ADC value of the IPR. *P* values less than .05 were considered statistically significant. Statistical analysis was performed with Statistical Package for the Social Sciences 16.0 for Windows.

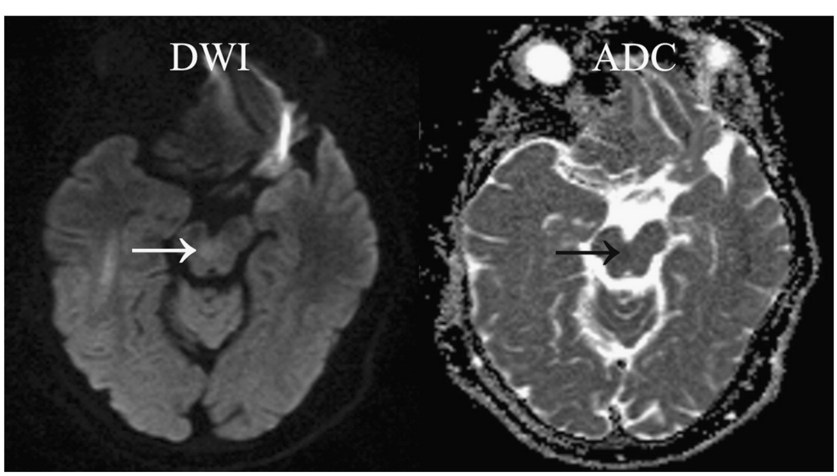

Fig. 2. Axial DWI (TR/TE=3200/94 ms, b=1000 s/mm^2, phase encoding direction with right to left) and corresponding ADC map without neurological findings. The IPR of the midbrain (IPR) displayed high signal in a 65-year-old woman (white arrow), relative to the PAG. The ADC value of the IPR was 0.67×10^{-3} mm^2/s on the corresponding ADC map (black arrow).