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What can be achieved by using MR-DWI and ADC value in cases of intramedullary spinal cord lesions of non-traumatic causes?

Faten Fawzy Mohamed[a], Hosam N. Almassry[a,*], Ayman M. Ismail[b]

[a] Radiology Department, Zagazig University, Egypt
[b] Neurosurgery Department, Zagazig University, Egypt

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ABSTRACT

Background: Early diagnosis and management of intra medullary spinal cord lesions is crucial for improving the outcome. This can be achieved by adding DW-MRI to spinal imaging protocol.
Patients & methods: A prospective study included 42 patients proved to have intramedullary SOLs of non-traumatic causes based on cMRI, were subjected to DWI and ADC value measurement. Our findings were correlated to the clinical outcome in non-neoplastic lesions and o the histopathological results in neoplastic lesions.
Results: 20 cases of non-neoplastic lesions (group I) showed nonrestricted diffusion with variable increased ADC values (mean = 1.46 ± 0.35 × 10^3 mm^2/s), except in cord acute ischemia which had restricted diffusion and reduced ADC value (mean = 0.85 ± 0.07 × 10^3 mm^2/s). 22 cases of neoplastic lesions (group II) showed reduced ADC values (mean 1.05 ± 0.21 × 10^3 mm^2/s), the lowest was in metastatic lesions (mean 0.75 ± 0.15 × 10^3 mm^2/s) and medulloblastoma (mean 0.81 ± 0.09 × 10^3 mm^2/s) while a diagnostic overlap occurred between astrocytoma and ependymoma (mean 1.19 ± 0.07, 1.1 ± 0.07 × 10^3 mm^2/s respectively). A cut off value 1.25 × 10^3 mm^2/s was found to differentiate between the two groups.
Conclusion: Optimum diagnosis for non-traumatic intra-medullary spinal cord lesions can be achieved by using DWI and ADC value measurement.

1. Introduction

Spine and spinal cord pathologies are usually imaged using magnetic resonance and the differential diagnosis of neoplastic and non-neoplastic lesions is mostly based on morphological criteria [1].

Conventional Magnetic Resonance Imaging (cMRI) sequences lack sensitivity in detecting and characterizing spinal cord lesions as multiple sclerosis or acute spinal cord ischemia and it may not be able to define precisely the zone of transition between the tumor and the surrounding edematous changes [2].

Diffusion-weighted MR imaging (DWI) increases the sensitivity and specificity of cMRI in diagnosis and characterization of different spinal cord lesions [3], as it adds functional data obtained at the cellular level, based on water molecular motion within tissues to aid in the differentiation of normal and pathological tissues [4].

Quantitative data of DWI can be achieved by measuring the apparent diffusion coefficient (ADC), which reflects tissue cellular capacity [5] and helps in characterizing spinal cord lesions as myelopathy, intramedullary neoplasms, demyelinating diseases [6] to assess the feasibility of surgical resection, medical treatment, and follow-up [2].

Noninvasive imaging modality that can help differentiate malignant soft tissue tumors from benign lesions as well as malignant grading [7]. It allows for measurement of tissue microstructures and reflects the random water molecular motion using ADC value as a quantitative parameter [8].

Significantly higher ADC values were found in benign soft tissue masses relative to the malignant tumors, despite some overlap in their ADC values. The difference in ADC values reflects the size of extracellular space. Malignant soft tissue tumors tend to have a lower ADC value due to increased tumor cell packing which restrict the normal Brownian molecular motion in the extra-cellular space [7].

Low pre-treatment ADC values typically predict a favorable outcome to chemo-radiotherapy [9].

The aim of this study is to assess the role of DWI and ADC measurement in diagnosis and characterization of intramedullary spinal cord lesions and in narrowing the differential diagnoses.

2. Patients and methods

A prospective study, approved from our hospital institutional

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* Corresponding author.
E-mail address: hosamelmassry@gmail.com (H.N. Almassry).

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Table 1
Pathological entities of the 42 cases based on cMRI.

Group 1 non neoplastic (No: 20) Lesion	N (%)	Group II neoplastic (No: 22) Lesion	N (%)
Transverse myelitis	5(25%)	Astrocytoma	8(36.4%)
MS	6(30%)	Eymoma	5(22.7%)
Acute ischemia	2(10%)	Medulloblastoma	4(18.2%)
Syringomyelia	3(15%)	Hemangioblastoma	2(9.1%)
Disc compressive myelopathy	4(20%)	Metastatic	3(13.6%)

Table 2
Signal Intensity of the pathological entities on DWI and ADC map.

The lesion	N	DWI (%)		ADC map N (%)	
Group I					
Transverse myelitis	5	Hypointense	5 (100%)	Hyperintense	5 (100%)
MS	6	Hyperintense	3 (50%)	Hyperintense	6 (100%)
		Hypointense	3 (50%)		
Acute ischemia	2	Hyperintense	2 (100%)	Hypointense	2 (100%)
Syringomyelia	3	Hypointense	3 (100%)	Hyperintense	3 (100%)
Disc compressive myelopathy	4	Hypointense	4 (100%)	Hyperintense	4 (100%)
Group II					
Astrocytoma	8	Hyperintense	5 (62.5%)	Hypointensec	
		Isonintense	3 (37.5%)		
Eymoma	5	Hyperintense	5 (100%)	Hypointense	4 (80%)
				Isointense	1 (20%)
Medulloblastoma	4	Hyperintense	4 (100%)	Hypointense	4 (100%)
Hemangioblastoma	2	Isointense	1 (50%)	Hypointense	2 (100%)
		hyperintense	1 (50%)		
Metastatic	3	Hyperintense	3 (100%)	Hypointense	3 (100%)

review board, was conducted in Radiodiagnosis Department, Zagazig University Hospitals in the time frame from January 2016 till October 2017 and included 42 patients proved by cMRI to have abnormal intra-medullary cord signal intensity of non-traumatic insults, referred from Neurosurgery Department, Neurology Department and outpatient clinics. Their age ranged from 11 to 68 years (mean age 35.4 ± 17.2), 22 male patients and 20 female patients. An informed consent was obtained from each patient before participating in the study.

2.1. MR imaging

MRI studies were done using Philips MR machine (1.5T).

2.1.1. Conventional magnetic resonance imaging (cMRI)

Preliminary to diffusion MRI, sagittal images were acquired with a 4 mm slice thickness, 380 mm field of view, 256 × 512 matrix and the following sequences: T1WI spin echo (600/12 m/s TR/TE) and T2WI (5000/120TR/TE).

2.1.2. Diffusion weighted MR imaging (DWI-MRI)

The imaging sequence for DWI was a multi-section single shot spin echo EPI sequence (TR/TE/NEX: 1600/95 ms/1), FOV 40 × 20, matrix 176 × 256, 5 mm thickness and inter-slice gap of 1 mm with diffusion sensitivities of b values = 0, 1000 s/mm^2 and a standard phased array surface receiver coil for imaging the spine was used.

The ADC maps were calculated automatically by MRI software and included in the sequence. Measurements of ADC were done automatically by applying a circular region of interest (ROI) in the center of the lesion and in the solid enhancing part relative to previous contrast-enhanced MR image, in order to obtain ADC values which were expressed in 10^{-3} mm^2/s and compared with a ROI placed on normally appearing area of the spinal cord as a control value.

2.2. Histopathological correlation

The cases subjected to surgical resection and histopathological analysis were correlated with the results obtained by diffusion MR imaging. Non-neoplastic lesions were evaluated with their clinical outcome after initiation of medical treatment.

2.3. Statistical analysis

The collected data were computerized and statistically analyzed using SPSS program (Statistical Package for Social Science) version 18.0. Qualitative data were represented as frequencies and relative percentages. Quantitative data were expressed as mean ± SD (Standard deviation). Indeent T-test and ANOVA test was used to calculate the difference between quantitative variables.

Receiver operating characteristic (ROC) curve analysis was used to identify optimal cut-off values of ADC with maximum sensitivity and specificity for prediction of the neoplastic lesions and AUC (area under the curve) and Reliability data were calculated (Sensitivity, Specificity,

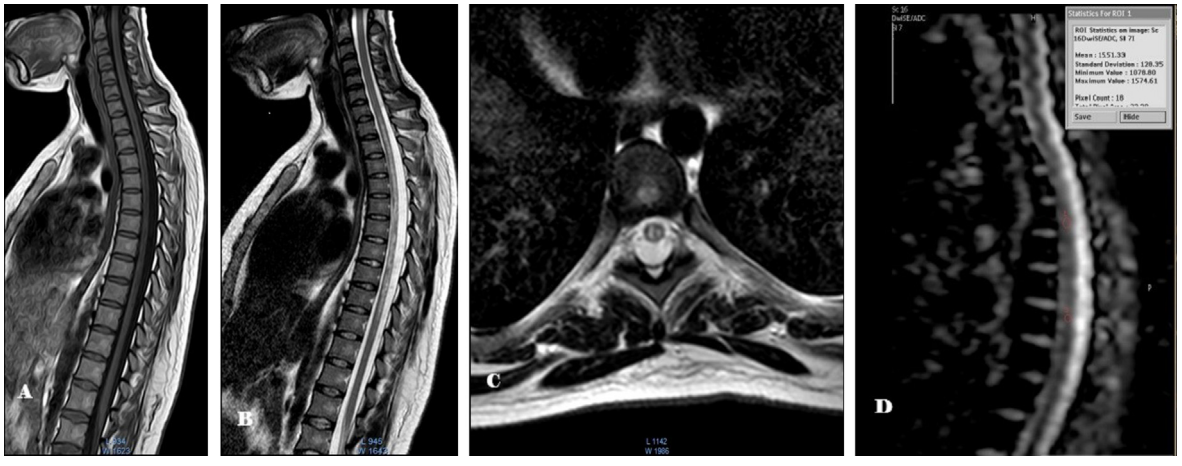

Fig. 1. Transverse myelitis
24-year-old female patient presented by tingling and numbness of both lower limbs 4 months duration; (A) Sagittal T1WI reveals diffuse abnormal subtle hypointense lesion at mid dorsal cord opposite D4-5 down to D7-8 levels with slight dilatation of central neural canal. (B): Sagittal and (C) Axial T2WI revealed hyperintensity of the intra-medullary lesion with no significant cord expansion. (D): Sagittal ADC map (b1000) displays hyperintense signal of the lesion with ADC value equals 1.55×10^{-3} mm^2/s in keeping with vasogenic edema and unrestricted diffusion.