The Egyptian Journal of Radiology and Nuclear Medicine (2015) **46**, 727–732

Egyptian Society of Radiology and Nuclear Medicine

The Egyptian Journal of Radiology and Nuclear Medicine

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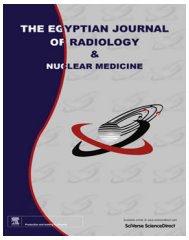

ORIGINAL ARTICLE

The value of added opposed/in phase MRI sequences in characterization of the focal vertebral bone marrow lesions in oncology patients☆

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Received 1 February 2015; accepted 4 May 2015
Available online 27 May 2015

KEYWORDS

Opposed/in phase;
Focal marrow lesions;
Oncology patients

Abstract *Objective:* This study aimed to evaluate the value of added opposed/in phase MRI sequences with signal intensity ratio (SIR) calculations in differentiation malignant and benign vertebral focal marrow lesions in oncology patients.
Patients and methods: From January 2013 to December 2014, a total of 50 oncology patients with 63 focal spinal bone marrow lesions underwent MRI examination with added opposed/in-phase sequences. A computation of SIR of the marrow on the opposed phase to signal intensity measured on the in-phase images was made.
Results: The examined 50 oncology patients showed 63 focal lesions, 39 proved to be malignant and 24 diagnosed as benign. The majority of malignant lesions (32/39) showed persistence of the high signals at the opposed phase sequences while signal loss was noted on all benign lesions. SIR values were ranged between 1.1 and 2.6 in malignant lesions while it ranged from 0.47 to 0.9 in benign lesions; when a SIR of 1 as a cutoff was chosen, it showed high sensitivity and specificity (96.8% and 93.65% respectively).
Conclusion: The added opposed/in phase MRI sequences with SIR cut-off value of 1, were proved to be a non-invasive sensitive tool to differentiate between malignant and benign lesions in oncology patients.

1. Background

Pathological lesions of vertebral bone marrow usually replace, to a variable degree, its normal constituent (1). Such replacement could be neoplastic cells, inflammatory cells, water, as well as blood degradation products (2). MRI is an excellent non-invasive modality for evaluating bone marrow and detecting marrow lesions (3). MRI has the highest sensitivity for

☆ No disclosure of funding received for this work from any organization.
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Peer review under responsibility of Egyptian Society of Radiology and Nuclear Medicine.

http://dx.doi.org/10.1016/j.ejrnm.2015.05.004

detecting both diffuse and focal bone marrow involvement (4). In spite of its high sensitivity, MRI is of only limited specificity in the evaluation of bone marrow alterations. This limited specificity requires additional, sometimes invasive diagnostic steps to obtain accurate diagnosis (5). Opposed-phase GRE sequences have recently been shown to be sensitive for demonstrating red bone marrow pathology (6). In opposed phase GRE, fat and water resonate at different frequencies. By choosing the appropriate TE we can subtract fat from water during in and out of phase sequences (7). There is significant difference in signal intensity between benign compression fractures and malignancy on in-phase/opposed-phase MR imaging (8). In-phase/opposed-phase imaging of the spine should be a sensitive and specific way to differentiate benign from malignant lesions (9).

2. Objective

This study aimed to evaluate the value of addition of the in/opposed phase MRI sequences with signal intensity ratio (SIR) measurements in the characterization and differentiation between benign and malignant vertebral focal marrow lesions in oncology patients.

3. Patients and methods

From January 2013 to December 2014, a total of 50 consecutive oncology patients (31 women and 19 men), with suspicious spinal focal bone marrow lesions on conventional MRI examination were recommended for further evaluation for more characterization. The patients' ages ranged from 29 to 86 years, (mean ± 59 years).

3.1. MRI Techniques

- All MRI studies were performed by using a 1.5 Tesla superconducting Magnet (Philips Systems) in the following sequences:-
  1. Sagittal T1, (TR, 400; TE, 8),
  2. Sagittal T2, (TR, 3000, TE 100),
  3. Sagittal STIR, (TR: 3500, TE, 80; TI, 165),
  4. Sagittal in-phase (TR, 400; TE, 4.6; flip angle, 80°) and opposed-phase gradient recalled-echo sequences (TR, 400; TE, 2.3; flip angle, 80°) were acquired.

An equal sized region of interest (ROI) cursor was placed over the same area of abnormal bone marrow on the in-phase as well as on the opposed-phase images. A computation of the signal intensity ratio (SIR) of the marrow on the opposed phase to signal intensity measured on the in-phase images was made. Means and SDs were calculated for the relative SIR of the neoplastic and non-neoplastic groups and for the normal-appearing marrow.

- All patients were followed up until reaching the final clinical diagnosis.

The histo-pathologic diagnosis as well as the final clinical diagnosis was used as the "gold standard" to classify the vertebral bone marrow lesions as benign or malignant.

3.2. Statistical analysis

Sensibility, specificity and accuracy were estimated with confidence interval. To evaluate discriminate capacity of opposed-phase/in-phase ratio and SIR values, the cut-off point with maximum sensitivity and specificity for differentiation of malignant and benign bone lesions was calculated.

4. Results

This study included 50 oncology patients (31 female and 19 male) who were complaining of back-pain and conventional MRI studies showed abnormal bone marrow focal lesions on the spine, without definite characterization. The examined 50 patients showed 63 focal lesions, 39 proved to be malignant by histopathologic results except for non-accessible 4 lesions that were followed up for 3–9 months until reaching their final diagnosis by biopsy for 3 progressive lesions while one patient showed appearance of other multiple lesions on 2nd follow-up after 1 month and then died shortly so considered malignant according to the clinical diagnosis. Twenty-four lesions diagnosed as benign by clinical diagnosis after follow up over 18 months

Analysis of the spinal focal lesions according to the final diagnosis is shown in Table 1.

The imaging results of the spinal bone marrow lesions were variable according to its pathologic nature (Tables 2 and 3),

- The 39 neoplastic lesions, divided into 4 groups as follow:-
  a – Group 1, included 27 lesions which were finally diagnosed as metastatic lesions, (15 from breast cancer, 5 from thyroid cancer, 3 from prostate cancer, 3 from bronchogenic carcinoma and 1 from urinary bladder cancer). All the metastatic lesions showed decreased signal intensity compared with normal marrow on the T1WI and appeared iso-hyperintense signals on T2WI and STIR sequences except for 3 sclerotic metastatic lesions that appeared hypointense at both T1 and T2WI and iso-intense at STIR sequences.
  *At in/opposed phase images 24 lesions remained hyperintense at the opposed phase while the 3 sclerotic lesions showed loss of signals. The mean SIR for the metastatic lesions, ranged from 1.2 to 2.3 (Fig. 1), except for the 3 sclerotic lesions where SIR measurement was below 1.

Table 1 The final clinical and pathological diagnosis of all the 63 lesions.

Lesion final clinical diagnosis	Number of lesions
-Neoplastic:-	39
a – Metastases	27
b – Lymphoma	5
c – Multiple Myeloma (MM)	6
d – L. Histocytoma	1
-Non-neoplastic:-	24
-Osteoporosis compression fracture,	15
-Inflammatory destructive lesion,	3
-Post-traumatic fracture,	2
-Atypical hemangiomas	4
-Total	63