Role of Diffusion WIs and T₂* GRE Pulse Sequences in Dubious Vertebral Marrow Pathological Lesions

OMAR M. OSMAN, M.D.*; YASSER R. FAHMY, M.D.*; ALAA M. EL-ORABY, M.D.**; AYMAN A. EL-BASMY, M.D.* and YASSER E. AMIN, M.D.***

The Department of Radiology, Faculty of Medicine*, National Cancer Institute** and the Department of Rheumatology**, Faculty of Medicine, Cairo University, Egypt.

ABSTRACT

Pathological lesions of the vertebral bone marrow usually replace, to a variable degree, its normal constituents. This represents a diagnostic dilemma, predominantly in old patients with high possibility of osteoporotic vertebral collapse. In this study we assessed the potentials of diffusion weighted images (DWIs) and T₂* GRE WIs in differentiation of such pathological changes. The difference between trabecular bone and soft tissue produces distortions in magnetic resonance images according to susceptibility differences of the pathological component. This allows discrimination between benign and malignant lesions. So our purpose was to evaluate the addition of diffusion weighted images (DWIs) and T₂* GRE WIs for differentiation of benign from malignant vertebral lesions; to endorse the role of MR in such lesions. One hundred cases at different radiological centers were evaluated using the same specified parameters. Our results showed that addition of diffusion and T₂* GRE WIs to MRI sequences can differentiate, to a certain degree, between bone marrow pathological lesions.

Conclusion: Diffusion WIs and T₂* GRE pulse sequences can be added to previous MRI pulse sequences to support discrimination between vertebral marrow pathological lesions.

Key Words: DWIs – T₂*GRE WIs – Pathological bone marrow lesion.

INTRODUCTION

Pathological lesions usually replace normal components of the vertebral bone marrow [1]. Such replacement could be neoplastic cells, inflammatory cells, water, as well as blood degradation products. Therefore, the signal detected would be changeable to a certain degree depending on the amount and type of cells. Neoplastic and inflammatory cells usually replace all the normal fat in the bone marrow [1-7]. In opposed phase gradient echo, 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 [8]. This is most profound when the amount of water and fat in each voxel is similar, as in the bone marrow.

Susceptibility differences between trabecular bone, soft tissue and blood degradation products also create localized distortions of the magnetic field which induce strong inhomogeneities in the static magnetic field [1]. Diffusion and T₂* GRE sequences of such magnetic field gradients produce distortion of dephasing. So, both sequences produce shortening of the apparent relaxation time T₂. This can be exploited to the maximum benefit by using diffusion and T₂* GRE WIs in diagnostic imaging of marrow replacing lesions. Hence, adding such modified MRI sequences can help to solve such problem [1-7].

So our aim was to evaluate the addition of diffusion weighted images (DWIs) and T₂* GRE WIs in differentiating benign from malignant vertebral lesions, as well as to endorse role of MR in such lesions.

MATERIAL AND METHODS

We evaluated 100 cases using medium and high field machines, 1, 1.5 and 3 T machines, between June 2005 and June 2007, at EL Iman Radiology Center at Bani swaif and Fayoum...
Role of Diffusion WIs & T2* GRE Pulse

In diffusion WIs both types of osteoporotic fracture showed limited diffusion restriction (Fig. 7), while T2* GRE showed increase magnetic susceptibility, predominantly in acute fractures, with 100% specificity and sensitivity (Fig. 8).

Spondylodiscitis showed intermediate diffusion restriction, with no magnetic susceptibility T2* GRE sequences. Malignant lesions, on the other hand, showed marked diffusion restriction with no magnetic susceptibility detected in T2* GRE sequences (Fig. 9).

Diffusion studies showed high sensitivity and specificity for differentiation of neoplastic and inflammatory processes (Figs. 10-12). Table (2) shows the collective different MRI signals in each group.

The observation agreements of neoplastic lesions between the two radiologist groups blinded to each others results, regarding opposed and diffusion sequences, combined and separately, were about 80% and 94.5%, respectively. Combination of the two sequences increased the agreement percentage to 96.3% in both groups. Only one inflammatory case (6.6%) was not diagnosed by opposed phase with one of the groups. This had been corrected by exploiting DWIs data. Both groups showed 100% agreement as regards the osteoporotic lesions and haemangiomas.

Table (1): The different pathological lesions of included patients.

<table>
<thead>
<tr>
<th>Pathological lesion</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteoporotic fractures</td>
<td>25 (25%)</td>
</tr>
<tr>
<td>Spondylodiscitis</td>
<td>15 (15%)</td>
</tr>
<tr>
<td>Giant high risk haemangioma</td>
<td>5 (5%)</td>
</tr>
<tr>
<td>Prostate metastases</td>
<td>15 (15%)</td>
</tr>
<tr>
<td>Breast metastases</td>
<td>10 (10%)</td>
</tr>
<tr>
<td>Bronchogenic metastases</td>
<td>10 (10%)</td>
</tr>
<tr>
<td>Renal metastases</td>
<td>5 (5%)</td>
</tr>
<tr>
<td>Breast metastases with radiotherapy</td>
<td>5 (5%)</td>
</tr>
<tr>
<td>Myeloma</td>
<td>5 (5%)</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>5 (5%)</td>
</tr>
</tbody>
</table>
Table (2): Collective different MRI signals of different pathological lesion in each group.

<table>
<thead>
<tr>
<th>Pathological lesion</th>
<th>Opposed phase</th>
<th>STIR</th>
<th>Diffusion</th>
<th>T2*GRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteoporotic fractures</td>
<td>Signal drop</td>
<td></td>
<td>Limited restriction</td>
<td>Magnetic susceptibility in acute trauma</td>
</tr>
<tr>
<td>Spondylodiscitis</td>
<td>No signal drop</td>
<td></td>
<td>Average restriction</td>
<td>No magnetic susceptibility</td>
</tr>
<tr>
<td>Giant high risk haemangioma</td>
<td>Signal drop</td>
<td></td>
<td>Average restriction</td>
<td></td>
</tr>
<tr>
<td>Prostate metastases</td>
<td>Bright</td>
<td></td>
<td>Significant</td>
<td></td>
</tr>
<tr>
<td>Breast metastases</td>
<td>Signal</td>
<td></td>
<td>Restriction</td>
<td></td>
</tr>
<tr>
<td>Bronch. metastases</td>
<td></td>
<td></td>
<td>(Bright signal)</td>
<td></td>
</tr>
<tr>
<td>Renal metastases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breast metastases with radiotherapy</td>
<td>No signal drop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myeloma</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lymphoma</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. (1): Trauma: signal drop in out phase.

Fig. (2): Infection: no signal drop in out phase.
Fig. (3): Haemangioma of a known case of breast cancer shows signal drop in out phase.

Fig. (4): Breast metastasis: no signal drop in out phase.
Fig. (5): Multiple myeloma: no signal drop in out phase.

Fig. (6): Lymphoma: no signal drop in out phase.
Fig. (7): Trauma: no diffusion restriction in DWIs.

Fig. (8): Acute trauma with blooming of blood degradation products in T2*.

Fig. (9): Infection with no blooming in T2*. 
Fig. (10): Breast metastasis with notable diffusion restriction in DWIs.

Fig. (11): Multiple myeloma with notable diffusion restriction in DWIs.
DISCUSSION

Pathological lesions of vertebral bone marrow usually replace, to a variable degree, its normal constituent. This poses a diagnostic dilemma, predominantly in old patients with a high possibility of osteoporotic vertebral collapse. The feasibility of MRI in depicting trabecular bone structure has been demonstrated in several studies. Conventional MRI sequence signal changes are usually subjective depending on morphology and predominant site of signal changes involvement. However, this sometimes does not solve the problem [9-14].

High or inhomogeneous signal intensities of compressed vertebral body on T2 weighted images and on contrast-enhanced MR images has been reported to be suggestive of malignancy on conventional spin-echo images [13]. This was contradictory to our study supported by previous results of Jung et al. [14] which revealed that signal intensity on fast spin-echo T2-weighted images played little role in distinguishing between acute benign osteoporotic and metastatic compression fractures.

Most of the literatures discussed the application of opposed phase gradient echo in the appendicular skeleton relying mainly on fat suppression. In vertebral bone marrow, with its main constituent’s red and yellow marrow, the technique depends mainly on separating fat signal from water signal [8-10]. Our results showed significant signal reduction for benign lesions with limited reduction for malignant lesions. This supports a previous study done by Lingawi and Ragab, revealing that opposed phase gradient echo sequence is useful in differentiating benign from malignant vertebral lesions [8].

In agreement with Mulligan et al. [12], our study showed that DWIs had about 80% sensitivity for differentiation between neoplastic and inflammatory processes. In our study, we found that both have diffusion restriction showing bright signals as compared to osteoporotic lesions. Additionally, it was easy to discriminate both depending on their signal variability. This can be attributed to the dense cellular components of tumors, as opposed to inflammatory lesions with relatively lower cellular component [12].

This study found that both observers were able to categorize vertebral marrow pathological lesions by opposed phase and STIR sequences with observers’ agreement about 80%. Combining them with DWIs sequences further increased the observers’ agreement to be about 96.3%. This, in our opinion, was due to improved pathological signal resolution due to tissue mixture variability. These findings were similar to those of Rodallec et al. [7] who proved that multiple sequences in different planes were helpful for delineating normal bone marrow architecture,
fat content within masses and subacute hemorrhage. They stressed that evaluating tissue enhancement, after administration of gadolinium-based contrast material, results in enhancement proportional to soft-tissue vascularity. This is helpful for differentiating cystic lesions from cyst-like solid masses. They asserted that dynamic contrast-enhanced MR imaging adds information about the rapidity of the enhancement. This could not be compared with our results, as it was not our target.

Our study found, in concordance with Rodallec et al. [7], that STIR is a very sensitive sequence for detecting most types of soft-tissue and marrow abnormalities of large field of view, e.g. full-spine. This was very useful in rapid screening assessment and diagnosis of multifocal lesions of the skeleton.

Recruitment of the magnetic susceptibility effect of T$_2^*$ GRE showed a significant difference between hemorrhagic and non hemorrhagic pathological processes [10-11]. It was proved to be 100% sensitive for differentiation between acute and chronic osteoporotic vertebral collapse supporting a previous report by Jung et al. [14]. In addition, this was helpful in diagnosis of vertebral hemangiomas, preferentially those of high risk, as increase in size leads to cord compression and structural collapse [7]. In our study we found that T$_2^*$ GRE had poor sensitivity in differentiating haemorrhagic and non haemorrhagic metastases. This could be exploited as an auxiliary sequence in differentiating acute trauma from neoplastic lesions of old osteoporotic patients.

Despite the use of different magnet strengths, we evaluated different pulse sequences, our target, regardless of the magnetic field strength. Though, we observed that diagnosis and differentiation was confidently much easier by 3 T machine. Yet, for a better and further conclusion, future comparative study of the same patient is recommended to standardize variables of each patient and machine.

In conclusion, addition of diffusion WIs and T$_2^*$ GRE help, opposed phase, MRI techniques can effectively characterize bone marrow pathological lesion without the need for invasive procedures.

REFERENCES


