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Acute vertebral compression fracture: differentiation of malignant and benign causes by diffusion weighted magnetic resonance imaging

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Original Article

Acute vertebral compression fracture: Differentiation of malignant and benign causes by diffusion weighted magnetic resonance imaging

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Abstract

Objective: To evaluate the sensitivity, specificity and accuracy of diffusion weighted (DWI) magnetic resonance imaging (MRI) in the diagnosis and differentiation between benign (osteoporotic/infectious) and malignant vertebral compression fractures in comparison with histology findings and clinical follow up.

Methods: The study was conducted at the Radiology Department, Aga Khan University Hospital (AKUH) Karachi. It was a one year cross-sectional study from 01/01/2009 to 01/01/2010. Forty patients with sixty three vertebral compression fractures were included. Diffusion-weighted sequences and apparent diffusion coefficient (ADC) images on a 1.5 T MR scanner were obtained in all patients to identify the vertebral compression fracture along with benign and malignant causes. Imaging findings were compared with histopathologic results and clinical follow-up.

Results: Diffusion-weighted MR imaging found to have, 92% sensitivity, 90% specificity and accuracy of 85% in differentiation of benign and malignant vertebral compression fracture while PPV and NPV were 78 % and 90% respectively.

Conclusion: Diffusion weighted magnetic resonance imaging offers a safe, accurate and non invasive modality to differentiate between the benign and malignant vertebral compression fracture.

Keywords: MRI, Diffusion weighted imaging, Compression fracture (JPMA 61:555; 2011).

Introduction

In our part of world vertebral collapse as a result of osteoporosis, infection or malignant disease either primary or metastates are common. Since the prognosis and management differs in these three entities, accurate diagnosis is important.[1] Conventional MR techniques cannot always be used to differentiate benign from malignant lesions because of their similar appearances as osteopenic or infective compression fracture can be indistinguishable with metastatic compression in the acute phase. Oedema in a benign compression fracture in the acute phase replaces the normal marrow giving hypo intensity on T1-weighted images and hyper intensity on T2-weighted images. The vertebral body with benign fracture may have enhancement after the IV administration of contrast material because of oedema and due to compensation as in any fracture. These MR signal intensity characteristics are similar to those of metastases and cause ambiguity, especially when only a single lesion is present.[2] The rationale for using DWI is that differences between benign and malignant fractures are mainly due to cellularity and the free water content. As DWI is highly sensitive to cellularity and free water molecule mobility, DWI should be useful in differentiating between vertebral body compression fractures caused by malignant (tumour) and benign (infection and osteoporotic) lesions.[3]

Even if DEXA scan is predicting osteopenia one cannot rule out malignant fracture and biopsy/histopathology is needed but with the help of DWI as stated earlier it can be very reliably differentiated and is noninvasive.

Subsequently, a small number of investigators have quantified the diffusion in abnormal vertebrae in terms of the apparent Diffusion coefficient (ADC) value and have concluded that quantitative assessment is more useful than qualitative assessment in differentiating benign vertebral fractures from malignant lesions. Data regarding the DWI imaging in differentiation of malignant versus benign vertebral fracture is limited especially from our part of world. Therefore the objective of this study was to evaluate the diagnostic accuracy of diffusion weighted MR imaging (DWI) in the diagnosis and differentiation between benign and malignant vertebral compression fractures by comparing the findings with histopathologic results and clinical (history, culture, dexa scan) outcome.

Patients and Methods

The study was done from January 2009 to January 2010.Forty consecutive patients with history of vertebral compression fracture detected clinically and by other imaging modalities were identified from radiology database and included in the study. Inclusion criteria were, DWI within 2 weeks from the time of presentation, no history of trauma (fall or road traffic accident), no end plate erosions, no

paravertebral enhancing collections.

Finally study group consisted of 22 men and 18 women, with ages ranging from 22 to 90 years. A total of 63 vertebral compression fractures were noted. The patients were imaged using the conventional T1 WI, T2 WI, fat suppressed contrast enhanced T1-weighted, and steady state free precession diffusion-weighted (SSFP DWI) sequences [using a body coil on a 1.5 Tesla super conducting MR System The SSFP DWI sequence used 18 NEX with a diffusion pulse length of 2 ms. The diffusion gradient was 24mT/m with a relatively low b value (500,800,1000). The 63 lesions were distributed in the dorsolumbar bodies with most occurring in the T10 to L4 vertebral bodies (50/63). The images obtained were analyzed by diffusion and ADC qualitatively. Initial evaluation was done by senior radiology resident and final report was made by consultant radiologist having experience of DWI reporting. The lesions were characterized as focal or multiple, with or without involvement of the vertebral elements. The signal intensities of the fractured vertebra were visually compared with that of the presumed normal vertebra on all (T1 WI, T2 WI, fat suppressed contrast [CE] enhanced T1-weighted and DWI) and categorized as hypo intense, isointense or hyper intense relative to the areas of presumed normal marrow. The medical records of these patients were reviewed to document the final diagnosis based on either or both clinical and labs (culture and sensitivity for infection, dexa scan for osteoporosis and histopathology for tumours. Data was collected in a predefined performa and entered in the SPSS V 16. Sensitivity, specificity, accuracy, PPV and NPV of DWI was calculated for differentiating malignant and benign (osteoporotic and infection) vertebral compression fracture.

Results

Of the 63 vertebral compression fracture noted in 40 patients, 19 collapses were because of benign cause (10 osteoporotic and 9 infection), while the remaining 44 were due to malignant etiology. With regards to the metastases: ten of the four unknown were primary, and four adenocarcinoma of colon, two squamous cell carcinoma lung, four prostate, four from breast, two from renal cell carcinoma and four from non Hodgkin's lymphoma. In addition, eight of collapsed vertebral bodies were due to multiple myeloma. Twenty six had a single lesion; while 23 patients had two or more lesions (there were seven patients who had more than two lesions). The signal intensities of the osteoporotic, infectious vertebral fractures on the DWI was low in 78.9% (15/19) lesions, isointense in 15.7% (3/19) lesions and hyper intense in only 5.2 % (1/19) lesions. In the malignant group, the fractured vertebral bodies were hyperintense in 81.8% (36/44) lesions and hypointense in 18.1% (8/44) cases, while there were no lesions which were isointense. In other words on DWI and

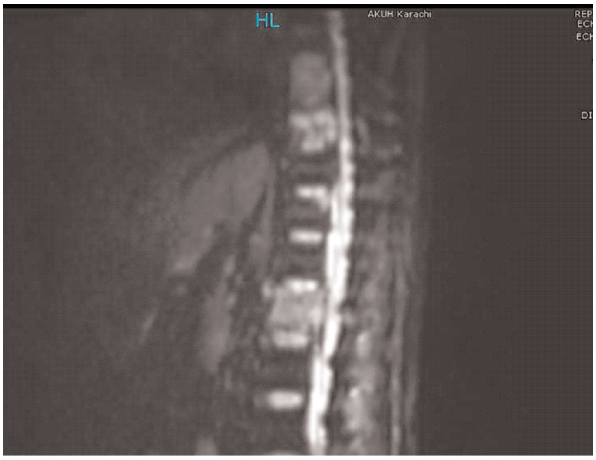

Figure-1A: A 65 years old female who presented with backache. DWI showing hyperintense signals in L2 vertebra suggestive of metastatic collapse. Histopathology showed adenocarcinoma metastasis.

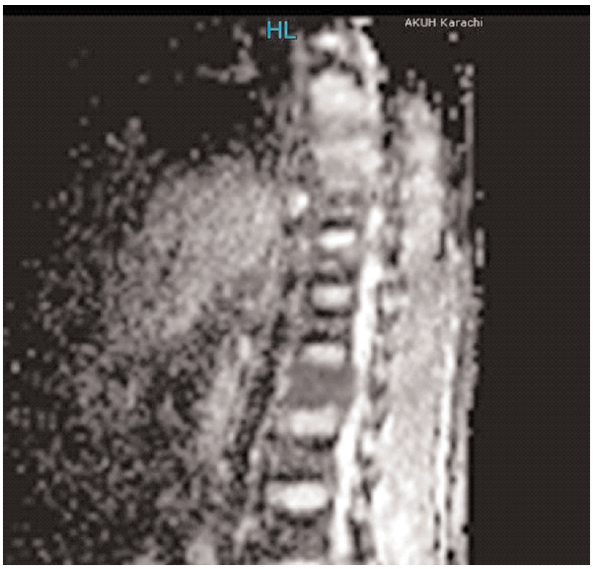

Figure-1B: Same patient on ADC showing hypointense signals in L2 vertebra suggestive of metastatic collapse.

ADC eight malignant lesions out of forty four were read as benign although they were proving to be malignant. Using the presence of high signal intensity on DWI as indicator of malignant disease, the sensitivity and specificity of DWI was 92% and 90% respectively. The positive predictive value of high signal on DWI for malignant fractures was 78% while the negative predictive value was 90%.

Using the presence of low signal intensity on DWI as indicator of osteoprotic collapse disease, the sensitivity and specificity of DWI was 75% and 85.7% respectively. The

positive predictive value of low signal on DWI for osteoprotic fractures was 90% while the negative predictive value was also 66% with accuracy of 78.9%.

Using the presence of low signal intensity on DWI as indicator of infectious collapse, the sensitivity and specificity of DWI was 85.7% and 75% respectively. The positive predictive value of low signal on DWI was 66% while the negative predictive value was also 90% with accuracy of 78.9%.

Discussion

To diagnose cause of vertebral collapse is of paramount clinical importance because benign and malignant collapses have different management and outcome. This is particularly important in the elderly patients who are predisposed to benign compression fracture caused by osteoporosis, where establishing the correct diagnosis is of value in determining treatment, surgical approach, and prognosis. The list of differentials for collapse is diverse, but a thoughtful history and detailed examination can narrow it down to enabling, suitable and gainful investigations and referral to the correct speciality.[4,5] MR imaging using conventional T1 WI and T2 WI has proven helpful in differentiating between benign and malignant causes of vertebral collapse but confident diagnosis is not always possible.[3] When assessing contrast enhanced MRI, benign vertebral fractures may also enhance after intravenous administration of contrast media due to a breach in blood tissue. Dynamic contrast enhancement has been evaluated in the characterisation of lesions in the brain, liver breast, pelvis, etc, this has not been evaluated in the spine.[6,7] Over the last decade, DWI MR imaging of the vertebral body has proved its value and has been successfully implemented for the differentiation of benign and malignant fracture oedema (due to tumour infiltration).[8] DWI MRI provides unique tissue characterisation that is complementary to that provided by conventional MR Imaging and is sensitive to micro-structural changes. The reduced mobility of water in pathologic fracture is the result of tumour cell accumulation and subsequent reduction in the interstitial spaces that results in high signal intensity compared with normal bone marrow. On the other hand, the increased mobility of water attributed to an increase in the interstitial space in relation to oedema or haemorrhage[9] in benign fractures[10-12] results in low signal intensity in benign osteoporotic and traumatic fractures. On this basis DWI MRI has been suggested to be useful particularly in the evaluation of vertebral lesions.Bauer et al[13] found 100% accuracy in the diagnosis of malignant compression fractures using SSFP DWI. They also showed that even though T1 Weighted spin echo and T2 Weighted STIR scans detected all fractures, there was no discriminating power based on signal intensity or bone marrow contrast ratio. In our study, we found that the SSFP DWI sequences showed a high diagnostic accuracy in differentiating acute benign osteoporotic fracture from pathological fractures with sensitivity of 92%, specificity of 90% with a PPV of 78%. The ADC of normal vertebrae is significantly higher than that of vertebral metastases and it is proposed that ADC is a dependable and quantifiable parameter with which to distinguish metastases[14] and ADC maps appear to be a reliable tool in differentiation of benign and malignant fractures.[15] We were unable to determine the ADC values. Histological diagnosis could not be confirmed in all patients as it was not possible to obtain consent for biopsies especially in those with a diagnosis of osteoporotic fractures. But with follow-up of those without biopsies this limitation could be overcome. DWI may exhibit hyperintensity in infectious disease similar to tumourous fracture in vertebral bodies.[16,17] While false Negativity may be accounted for by previous radiotherapy (due to necrosis as compared with viable tumour) or due to excessive fibrosis and bleeding. Moreover, the signal intensity on DWI MR Images depends on the b factor, which is strongly influenced by hardware components, imaging parameters and the pulse sequence itself.[18] This limits comparison between subsequent investigations, for example, follow up studies and monitoring. When the findings on routine MR sequences are not completely conclusive for the diagnosis of benign or malignant vertebral body compression fracture, then the use of both contrast enhancement and diffusion weighted MR sequence may be helpful.[19]

Our study has few limitations beside single center and small sample size. No quantitative measurements were made for DWI and ADC values of lesions. Inter observer agreement amongst the radiologists was not calculated for DWI interpretations.

Conclusion

Diffusion weighted magnetic resonance imaging is an excellent non-invasive modality to differentiate vertebral compression fracture from benign and malignant causes, and the presence of iso- or hypo intensity of the collapsed vertebral bodies is suggestive of a benign lesion while hyper intensity is highly suggestive of malignancy. Similiarly low signals on ADC are highly suggestive of collapse from a malignant cause.

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