ROLE OF MRI DIFFUSION-WEIGHTED IMAGING AND COLOR DOPPLER ULTRASONOGRAPHY IN CHARACTERIZATION OF MUSCULOSKELETAL TUMORS

Thesis

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Abstract

Purpose: To evaluate the signal characteristics of MRI diffusion-weighted sequences of musculoskeletal tumors and its ability to differentiate between benign and malignant lesions and study of their vascularity and perfusion by color Doppler ultrasonography

Material and methods: The MR imaging protocol including the conventional T1 weighted (T1W), T2-weighted (T2W) and diffusion weighted (DW) echo-planer imaging (EPI), and contrast-enhanced T1W images. DWI was obtained before contrast medium injection, with *b* values including 50, 400 and 800 mm^2/second. The Apparent Diffusion Coefficient (ADC) generated by measuring identical images at different b-values and represented as ADC map from which ADC value calculated.

Diagnostic gray-scale US was performed to assess margin, growth pattern and internal echotexture of the tumor. The vascular pattern of each tumor was assessed by using color Doppler US.

Results: There were highly significant difference of the ADC value for soft tissue tumors between benign and malignant tumors ($P<0.01$). Two threshold values for ADC soft tissue tumors were obtained at cut off value 1.50, the sensitivity is 75%, the specificity is 70% and the efficacy is 66.6 %. And on cut off value 1.57, the sensitivity is 87.5%, the specificity is 60% and the efficacy is 77.6%. There were highly significant difference in RI of soft tissue tumors between benign and malignant tumors ($p<0.01$). The RI cut off value 0.64 shows sensitivity 75%, specificity 85% and efficacy 80 %. There were highly significant difference for ADC values of bone tumors between benign and malignant tumors ($P<0.01$). Threshold value of ADC bone tumors at 1.58 showing sensitivity, specificity and efficacy about 76.1%, 80% and 77.4% respectively. In follow up of one patient with bone tumor after therapy we found increase in ADC value measurement.

Conclusion: DWI with ADC mapping proved valuable information in differentiating benign from malignant lesion with highly significant difference between ADC value of benign and malignant lesion. Doppler study and spectral wave analysis will increased the sensitivity and specificity in evaluation of soft tissue tumors.

Keywords:

Magnetic resonance image (MRI)-Soft tissue tumors-Bone tumors-Diffusion weighted imaging (DWI)-Apparent diffusion coefficient (ADC)-Ultrasound-Doppler.

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LIST OF ABBREVIATIONS

%	Percentage
3T	3 Tesla
ABC	Aneurysmal bone cyst
ADC	Apparent Diffusion Coefficient
AJCC	American Joint Commission On Cancer
BPNST	Benign Peripheral Nerve Sheath Tumor
CDFI	Color Doppler Flow Imaging
CT	Computed Tomography
DTI	Diffusion Tensor Imaging
DWI	Diffusion-weighted imaging
EPI	Echo Planer Imaging
FNAB	Fine-needle aspiration biopsy
G	Strength of diffusion gradient (gradient amplitude)
GCT	Giant Cell Tumor
GCTTS	Giant Cell Tumor Of The Tendon Sheath
HHV8	Human Herpes Virus 8
HIV	Human Immunodeficiency Virus
HPF	High Power Field
IEPI	In Interval Echo-Planar Imaging
IV	Intravenous
IVIM	Intravoxel incoherent motion
LSDI	Line Scan Diffusion Image
MFH	Malignant Fibrous Histiocytoma
MHz	Megahertz
min	Minute
mm2	Square millimeter
MR	Magnetic Resonance
MRI	Magnetic Resonance Image
PNET	Primitive Neuroectodermal Tumors
PNST	Peripheral Nerve Sheath Tumor
RF	Radiofrequency
RT-PCR	Reverse Transcriptase-Polymerase Chain Reaction
SE	Spin Echo
SEER	Surveillance, Epidemiology, and End Results Program
SENSE	Sensitivity Encoding
SI	measured intensity (at maximal b-value)

SI_0	Intensity at G= 0 (from b=0 image).
SPAIR	Spectral presaturation attenuated by inversion recovery
SSFP	Steady State Free Precession
STIR	Short Tau Inversion Recovery
SWA	Spectral Wave Analysis
T1 WI	T1 weighted images.
T2 WI	T2 weighted images.
t_{diff}	Diffusion time
TE	Echo time
TM	Maximum time (for diffusion gradient)
US	Ultrasound
Vs	Versus
WHO	World Health Organization
α	Flip angle
γ	Proton gyromagnetic ratio (42 MHz/Tesla).
δ	duration of each gradient lobe
Δt	Interval of diffusion gradient.

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INTRODUCTION

Magnetic resonance imaging (MRI) is the method of choice for the diagnosis and follow up of bone and soft tissue tumors. Due to high contrast resolution, soft tissue masses can be easily detected and separated from normal tissues e.g. fat and muscles. After surgery or radiation of malignant soft tissue tumors, there are often marked changes of signal in the adjacent normal tissue due to edema or inflammation. The task for follow up MR examination is to detect a residual or recurrence of the tumor differentiating it from post operative and post radiotherapy changes. With conventional MR sequence, such as T1 and T2weighted images or fat suppression techniques, it is sometimes difficult to distinguish tumor recurrence from post therapeutic changes ***(Baur et al., 2001).***

Intravenous administration of MR contrast agents as those containing gadolinium chelates has been used as an alternative technique to improve tissue contrast by highlight viable, perfused tissue against tumor necrosis ***(Erlemann et al., 1990)***. However, since the contrast agents that are clinically available are of small molecular size, they are distributed in the interstitial space and can diffuse into necrotic tissue, thereby potentially obscuring tumor necrosis on conventional, static contrast agent-enhanced MR images. Rapid sequential imaging technique after bolus administration of gadopentate dimeglimine (i.e. dynamic MR imaging) may be more accurate in assessing tumor necrosis. However, the use of contrast agents increase the cost of the imaging procedure and requires the performance of additional MR sequence, with the resultant increase imaging time, cost and discomfort to the patient ***(Verstraete et al., 1994).***

Diffusion-weighted images are a relatively new method, which reflects intravoxel incoherent motion (IVIM). In biological tissues, motion includes Brownian motion of extra-, intra and transcelluar individual water molecules (true diffusion) as well as microcirculation of blood (perfusion). Both true diffusion and perfusion contribute to the frequently used apparent diffusion coeficient (ADC) ***(Catherina et al., 2002).***

Diffusion-weighted MRI has been used successfully in the central nervous system especially in the diagnosis of acute stroke, also in distinguishing different component of brain tumor ***(Gonzalez et al., 1999).***

Diffusion measurements of tumors outside the brain have also been reported. A study of osteogenic sarcoma in rats by ***Lang et al., 1998*** indicates that diffusion weighted MRI can accurately differentiate between viable and necrotic tumor region.

Moreover***; Bauer et al., 1998*** report diffusion measurements in human spine that could reliably differentiate acute benign from neoplastic vertebral compression fractures**.**

Post therapeutic soft tissue changes may pose a problem in the distinction from early tumor recurrence since all these pathologies have high signal intensity on T2 weighted and STIR images and low signal intensity on T1 weighted SE images ***(Roberts., 1997).***

In detection of musculoskeletal masses, especially soft tissue masses, ultrasonography is readily available, inexpensive, and noninvasive modality. In this respect, although not widely used, it's also useful in assessment bone tumors with an associated soft tissue mass ***(Van der Woud & Vanderschueren, 1999).***

The introduction of color Doppler flow imaging (CDFI) has result in the ability to assess the degree of vascularization and intra tumoral blood flow of solid masses. In addition, power Doppler sonography may add benefit due to improved signal to noise ratio relative to conventional Doppler techniques. Power Doppler sonography particularly allows visualization of areas of hyperperfusion, for instance those associated with musculoskeletal inflammatory disease ***(Newman et al., 1994).***

CDFI and power Doppler ultrasound may also play a role in monitoring the effects of neoadjuvant chemotherapy in patients with sacrcoma of bone or soft tissues, based on changes in tumoral vascularization and perfusion ***(Van der Woude et al., 1995).***

AIM OF THE WORK:

The aim of this study is to evaluate the signal characteristics of MRI diffusion-weighted sequences of musculoskeletal tumors and its ability to differentiate between benign and malignant lesions and study of their vascularity and perfusion by color Doppler ultrasonography.