Recent Advances in the Imaging of Multiple Myeloma

Essay
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التطورات الأخيرة في تصوير المايلوما المتعددة

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18F	Fluorine -18
3D	Three dimensional
99mTc	Technetium 99m
ADC	Apparent diffusion coefficient
AL	Amyloid light chain
BAT	Brown adipose tissue
BM	Bone marrow
BME-MAX	Bone marrow enhancement - maximum
CNR	Contrast to noise ratio
CNS	Central nervous system
cP	Centipoise
CSF	Colony stimulating factor
CT	Computer tomography
CTM	Continuous table movement
DCE-MRI	Dynamic contrast enhanced magnetic resonance imaging
DKK-1	Dickkopf-1
D-S	Durie and Salmon
DTPA	Diethylene-triamine-penta-acetic acid
DVT	Deep venous thrombosis
DWI	Diffusion weighted imaging
DWIBS	Diffusion weighted whole body imaging with background suppression
EPI	Echo planar imaging
ESR	Erythrocyte sedimentation rate
Fc	Fragment crystallizable
FDG	Fluorodeoxyglucose
FL	Focal lesion
FLE-MAX	Focal lesion enhancement - maximum
FOV	Field of view
Gd	Gadolinium
Ig	Immunoglobulin

List of Abbreviations (Cont.)

IGF-1	Insulin like growth factor-1
IL	Interleukin
IL-1	Interleukin-1
IL-6	Interleukin-6
kg	Kilogram
MBq	Megabecquerel
MC	M protein component
mCi	Millicurie
MDCT	Multi-detector computer tomography
MDP	Methylene diphosphate
MGUS	Monoclonal gammopathy of undetermined significance
MIP	Maximum intensity projection
MM	Multiple myeloma
mmol	Millimole
MPG	Motion probing gradient
MPR	Multiplanar reformatting
MRI	Magnetic resonance imaging
NFkB	Nuclear factor kappa B
NPO	Nil per os
OAFs	Osteoclast activating factors
OPG	Osteroprotegerin
PACS	Picture archiving and communication system
PET	Positron emission tomography
PET/CT	Positron emission tomography/computer tomography
POEMS	Polyneuropathy, organomegaly, endocrinopathy, monoclonal gammopathy and skin changes
PTH	Parathyroid hormone
PTHrP	Parathyroid hormone related protein
RANKL	Receptor activator of nuclear factor kappa B ligand

List of Abbreviations (Cont.)

RBC	Red blood cell
ROI	Region of interest
RSS	Radiographic skeletal survey
SDF-1	Stromal derived growth factor-1
sestaMIBI	Sesta methoxy-iso-butyl-isonitrile
SNR	Signal to noise ratio
SPECT	Single photon emission computed tomography
STIR	Short time inversion recovery
TE	Time for echo
TGF-β	Transforming growth factor beta
TNF-α	Tumor necrosis factor alpha
TR	Time for repetition
TSE	Turbo spin echo
VEGF	Vascular endothelial growth factor
VIBE	Volumetric interpolated breath-hold examination
WBC	White blood cell
WB-MRI	Whole body magnetic resonance imaging

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Chapter 1
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Introduction

Multiple myeloma (MM) is a B cell neoplasm characterised by the proliferation and accumulation of plasma cells in the bone marrow and by the overproduction of monoclonal immunoglobulins that can be detected in serum and/or urine ***(Nanni et al., 2006).*** Multiple myeloma accounts for approximately 10% of haematological malignancies and shows a peak incidence during the seventh decade. Approximately 5%–10% of patients have a solitary plasmacytoma ***(Schirrmeister et al., 2002).*** The clinical presentation of MM includes bone pain, recurrent or persistent infections, anemia, weakness and renal impairment or a combination of these symptoms ***(Ghanem et al., 2006).***

Determination of the total number of lesions is critical for staging purposes, as the treatment and prognosis is different for different types of myeloma, depending on precise staging. In the past, evaluation of the extent of osseous disease has relied primarily on the conventional radiographic skeletal survey ***(Breyer III et al., 2006)*** which was found to have limitations in evaluating early disease , and several studies have shown that multifocal disease may be present despite normal radiographs ***(Bredella et al., 2005).*** Conventional radiography also suffers from a relatively high false negative rate, leading to significant underestimation in diagnosing and staging of patients with multiple myeloma. Another disadvantage of radiographic technologies is that history and activity status of myeloma cannot be estimated ***(Piekarek et al., 2009).***

As a result, new imaging modalities have been examined in the management of multiple myeloma aiming for better management of this condition.

Magnetic resonance imaging (MRI) was found to be sensitive and effective diagnostic method with an important impact on staging and further treatment of multiple myeloma ***(Piekarek et al., 2009).*** It was also found to have a prognostic significance; the number of lesions on MRI correlates very well with treatment outcome and overall survival of patients with multiple myeloma ***(Lütje et al., 2009).***

Whole-body multi-detector computer tomography (MDCT) is superior to skeletal X-ray in detecting osteolytic lesions and in determining overall stage of multiple myeloma. Furthermore, additional findings could be seen detectable on whole body MDCT like emphysema, lymphadenopathy or hepatosplenomegaly that cannot be detected on conventional skeletal survey ***(Lütje et al., 2009).***

Positron emission tomography (PET) and positron emission tomography/computed tomography (PET/CT) was shown to be useful in assessment of response to therapy and as a prognostic indicator, especially in the setting of extramedullary disease ***(Shortt et al., 2009)***. It is also able to detect medullary involvement of multiple myeloma ***(Bredella et al., 2005).***

Tc-99m sestamibi imaging is also being increasingly utilized in the staging of the disease process as well as determination of remission in patients with multiple myeloma following chemotherapy ***(Kalaga et al., 2009).***

Aim of the Work

The aim of this work is to evaluate the recent advances in the imaging of multiple myeloma.

Chapter 2

Relevant MRI and PET Anatomy

Relevant MRI and PET Anatomy

MRI Anatomy of Bone Marrow

Normal Anatomy

The normal bone marrow has three primary components: osseous matrix, red marrow, and yellow marrow. The osseous components of the marrow are the trabeculae of cancellous bone, which provide the supporting framework for the red and yellow marrow elements. The red or cellular marrow is hematopoietically active, producing red blood cells (RBCs), white blood cells (WBCs), and platelet precursors. Hematopoietically inactive yellow marrow is composed of fat cells. These two types of marrow differ in their chemical composition. Recognition of these differences is important to understanding the MRI appearance of marrow. In infants and young children, red marrow consists of approximately 40% water, 40% fat, and 20% protein. As the individual ages, the fatty elements of hematopoietic marrow increase, and by age 70 years, red marrow is composed of approximately 60% fat, 30% water, and 10% protein. Yellow marrow contains approximately 80% fat, 15% water, and 5% protein. **(Siegel, 2000)**

MRI Appearance of Normal Marrow

The MR appearance of the bone marrow depends on the pulse sequence selection and the relative amounts of cellularity, protein, water, and fat within the