Diffusion Weighted Image MRI in Assessment of Patients with Multiple Myeloma

Thesis

Submitted for Partial Fulfilment of Master Degree in Radio-diagnosis

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2018

سورة البقرة الآية: ٣٢

Acknowledgment

First and foremost, I feel always indebted to **ALLAH**, *the Most Kind and Most Merciful.*

I'd like to express my respectful thanks and profound gratitude to ***Dr. Reem Hassan Basiouny,*** *Assistant Professor of Radiodiology - Faculty of Medicine- Ain Shams University for his keen guidance, kind supervision, valuable advice and continuous encouragement, which made possible the completion of this work.*

I am also delighted to express my deepest gratitude and thanks to ***Dr. Rasha Tolba Khattab,*** *Lecturer of Radiodiology, Faculty of Medicine, Ain Shams University, for his kind care, continuous supervision, valuable instructions, constant help and great assistance throughout this work.*

I would like to express my hearty thanks to all my family for their support till this work was completed.

Last but not least my sincere thanks and appreciation to all patients participated in this study.

Arwa Adel Mahmoud Hendy

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List of Abbreviations

Abb.	Full term
ADC	*Apparent diffusion coefficient*
DCE	*Dynamic contrast-enhanced*
DWI	*Diffusion weighted imaging*
Fs	*Fat-suppressed / fat-saturated*
MDCT	*Multidetector computed tomography*
MGUS	*Monoclonal gammopathy of undetermined significance*
MM	*Multiple myeloma*
M-protein	*Monoclonal protein*
MRI	*Magnetic resonance imaging*
SE	*Spin-echo*
SMM	*Smouldering multiple myeloma*
T1-weighted	*T1-weighted spin-echo*
T2-weighted	*T2-weighted spin-echo*

INTRODUCTION

Multiple myeloma (MM) is a hematologic malignancy characterized by abnormal plasma cells in the bone marrow and/or in extramedullary sites, urinary and/or serum monoclonal immunoglobulin, and osteolytic lesions in most patients. The Durie and Salmon staging system for MM, which was introduced in 1975, is still used to assess tumor burden and prognosis. The plain radiographic skeletal survey is an important part of this system, since multiple osteolytic lesions define stage III disease ***(Palumbo and Anderson, 2011; Rajkumar et al., 2014)***.

The prognostic implications of magnetic resonance (MR) imaging of the bone marrow for MM have already been established for abnormal versus normal MR imaging results and for individual MR imaging patterns of involvement ***Song et al., 2014)*** For example, abnormal spinal MR imaging results have been shown to help identify patients with asymptomatic (smoldering) myeloma who are likely to benefit from early treatment ***(Moulopoulos et al., 1995)***.

More recently, it was shown that patients with smoldering myeloma and more than one unequivocal focal lesion on whole-body MR images have an increased risk of developing myelomarelated symptoms and should receive treatment ***(Fechtner et al., 2010; Kastritis et al., 2014).*** Accordingly, the most recent International Myeloma Working

Group criteria for MM incorporate MR imaging findings in the definition of symptomatic disease ***(Rajkumar et al., 2014; Dimopoulos et al., 2015)***.

Diffusion-weighted imaging (DWI) with calculation of apparent diffusion coefficients (ADCs) may be used as an adjunct method to increase diagnostic confidence and to better distinguish a diffuse MR imaging pattern from a normal MR imaging pattern. So far, this technique has been applied to a relatively small number of patients with myeloma, with promising results for initial assessment and prognosis ***(Messiou et al., 2011a; Padhani et al., 2013)***.

Aim of the Work

To evaluate the apparent diffusion coefficients (ADCs) of magnetic resonance (MR) imaging patterns in the bone marrow of patients with multiple myeloma (MM) and to determine a threshold ADC that may help distinguish a diffuse from a normal pattern with high accuracy.

Chapter 1

ANATOMY OF THE SPINE & BONE MARROW

The spine is a vital functional unit that protects the spinal cord and supports the head, thorax, abdomen, and pelvis. Together, the rigid osseous structures combined with ligaments, disks, spinal cord, and spinal nerves facilitate complex motor and sensory functions required for life, be it work or play ***(Harnsberger et al., 2006).***

Vertebral Body Anatomy

Except in special circumstances, the vertebrae assume a relatively constant anatomic theme and consist of a vertebral body and a vertebral (neural) arch. The vertebral body serves as a pillar, supporting the head and trunk. The posterior margin of the bodies, along with the vertebral arches, forms the bony spinal canal, protecting the spinal cord. The neural arch is formed by paired pedicles and paired lamina. Seven processes arise from the vertebral arch: paired superior and inferior articular processes, paired transverse processes, and one spinous process. The intervertebral foramen, formed by two adjacent vertebrae, allows for passage of spinal nerves and vessels (Fig. 1-1 & 1-2)**.**

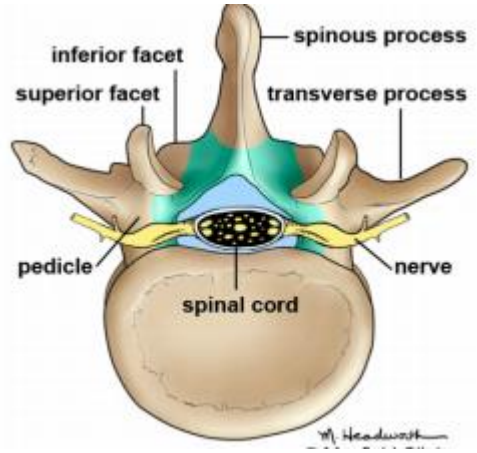

Fig. (1-1): Vertebral body.

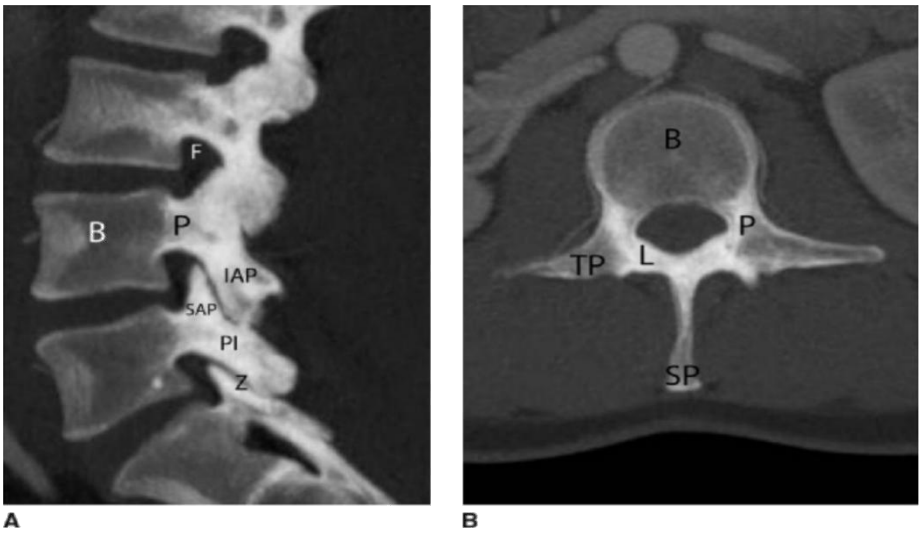

Fig. (1-2): A: Sagittal CT MIP of the lumbar spine demonstrating the vertebral body (B), pedicle (P), superior articular process (SAP), inferior articular process (IAP), and zygapophyseal joint (Z). The superior articular processes extend superiorly from the junction of the laminae and pedicles, while the inferior articular processes extend inferiorly from the undersurface of each lamina. The zygapophyseal joints are formed by the superior articular facet and the inferior articular facet. The pars interarticularis (PI) is the portion of the lamina between the superior and inferior articular processes. The intervertebral foramen (F) allows for the passage of spinal nerves and vessels. **:**Axial CT MIP of the lumbar spine demonstrating the vertebral body (B) and posterior neural arch. (P,pedicle; TP, transverse proocess; L, lamina; SP, spinous process).

The intervertebral discs consist of the inner nucleus pulposus and the outer annulus fibrosis. The main function of the disks is to distribute load and to allow flexion/extension and lateral bending. A remnant of the notochord, the nucleus pulposus, is usually located more dorsally compared to the center of the vertebral body. The annulus fibrosis attaches to the anterior longitudinal ligament (ALL) and posterior longitudinal ligament (PLL) and is also fused to the epiphyseal ring of the vertebral bodies. MRI of a normal disk demonstrates high signal on T2-weighted imaging related to the water content of the nucleus pulposus and inner annulus fibrosis. The outer annulus fibrosis demonstrates low signal on T1- and T2-weighted imaging (Fig 1-3) ***(Harnsberger et al., 2006)*.**

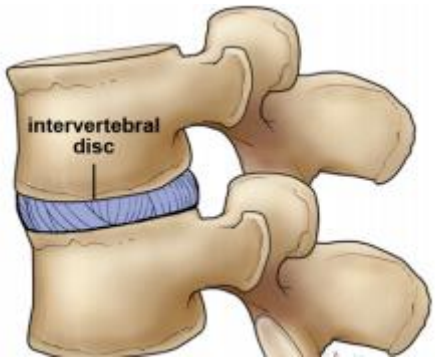

Fig. (1-3): Intervertebral disc