Imaging of Bone Marrow

Sopo Lin, MD[a], Tao Ouyang, MD[a], Sangam Kanekar, MD[a,b,*]

KEYWORDS

• Imaging • Bone marrow • Anatomy • Techniques • Pathology
• Hematological malignancies

KEY POINTS

- Bone marrow disorders or dysfunctions may be evaluated by blood workup, peripheral smears, and marrow biopsy.
- Noninvasive techniques such as plain radiograph, computed tomography (CT), MRI and nuclear medicine scan may also be used to evaluate bone marrow disorders.
- It is important to distinguish normal spinal marrow from pathology to avoid missing a pathology or misinterpreting normal changes, which may result in further testing and increased costs.

INTRODUCTION

Bone marrow is one of the largest organs of the human body. It serves the essential function of hematopoiesis. Its function is of vital importance for the normal functioning of the body as it continuously replenishes the cells required for oxygen delivery, excretion of waste/toxic material, various defense mechanisms, and maintaining the balance between the bleeding and clotting mechanism of the body. Bone marrow disorders or dysfunctions may be evaluated by blood workup, peripheral smears, and marrow biopsy. They may be also evaluated using noninvasive techniques such as plain radiographs, computed tomography (CT), MRI and nuclear medicine scan (single photon emission CT/PET). MRI, owing to its better soft tissue differentiation and higher spatial resolution, can evaluate marrow changes very early, thus giving a lead to the clinician regarding the undergoing disease process.

It is important to distinguish normal spinal marrow from pathology to avoid missing a pathology or misinterpreting normal changes, either of which may result in further testing and increased health care costs. On imaging, bone marrow pathologies may be classified into focal and diffuse (**Table 1**). In this article, we focus predominately

[a] Department of Radiology, Hershey Medical Center, The Pennsylvania State University, 500 University Drive, Hershey, PA 17033, USA; [b] Department of Neurology, Hershey Medical Center, The Pennsylvania State University, 500 University Drive, Hershey, PA 17033, USA
* Corresponding author. Department of Neurology, Hershey Medical Center, The Pennsylvania State University, 500 University Drive, Hershey, PA 17033.
E-mail address: skanekar@hmc.psu.edu

Hematol Oncol Clin N Am 30 (2016) 945–971
http://dx.doi.org/10.1016/j.hoc.2016.03.012 **hemonc.theclinics.com**
0889-8588/16/$ – see front matter

Table 1
Classification of bone marrow pathologies into focal and diffuse lesions

MR Signal Intensity	Focal Lesions	Diffuse Lesions
T1 hyperintense	Normal variant Focal fatty marrow Solitary hemangioma Degenerative disk disease Paget disease Melanoma metastasis Bone marrow hemorrhage Lipoma	Prior radiation treatment Osteoporosis Multiple hemangiomas Spondyloarthropathy Anorexia nervosa Chronic malnutrition
T1 Hypointensity	Degenerative endplate changes Osteomyelitis Amyloid Atypical hemangioma Fracture Malignancy Fibrous dysplasia Metastasis Myeloma Lymphoma Primary bone tumor Fracture	Hematopoietic hyperplasia Neoplasm Renal osteodystrophy Sarcoidosis Spondyloarthropathy Myelofibrosis Mastocytosis Hemosiderosis Gaucher disease Gout

on the diffuse bone marrow pathologies, because the majority of the bone marrow pathologies related to hematologic disorders are diffuse.

Bone Marrow Anatomy (Composition of Bone Marrow)

Normal bone structure consists of an outer cortex with an interior network of ossicles, referred to as trabecular, spongy, or cancellous bone. Approximately 80% of total bone volume consists of the compact cortical bone, and the remaining 20% is made up of cancellous or trabecular bone. By definition, trabecular bone refers to the structural network that partitions the space enclosed by the cortical bone. Trabeculae are thin and consist of segments formed by parallel lamellae. Bone marrow is a term used to refer to the tissue occupying the cavities between the trabecular bone.

Normal bone marrow is composed of red marrow, yellow marrow, osseous components, and a supporting system. Red bone marrow is the primary organ for the production of mature blood cells, and therefore represents hematopoetically active bone marrow. It is composed of 40% water, 40% fat, and 20% protein (Fig. 1). Red bone marrow has a definitive life span, and must be replenished by the body under normal circumstances. Yellow marrow represents hematopoetically inactive bone marrow. It is composed of 15% water, 80% fat, and 5% protein. Very few capillaries are present in the yellow marrow. With aging, there is a decrease in the number of trabeculae in bone, and subsequent conversion of red to yellow marrow.

Progression of Bone Marrow Changes from Childhood to Adult (Conversion)

At birth, red marrow is present throughout the entire skeleton. Normal physiologic conversion of red to yellow marrow occurs gradually from birth, and continues until adult age. As a general rule, marrow conversion first begins in the distal appendicular skeleton, beginning in the hands and feet and continues into the more proximal bones of the skeleton. By 25 years of age, the adult distribution of red marrow persists