The Influence of Patient Hydration on Tc-99m-MDP Bone Scintigraphy

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In Nuclear Medicine

by

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ABSTRACT

Keywords:

Bone scintigraphy; hydration; bone: soft tissue ratio; Tc99m MDP

The aim of this study was to establish whether hydration with fluid intake following radiopharmaceutical administration [Tc-99m MDP] has a real impact on the quality of skeletal scintigraphy. A hundred and forty three patients referred for bone scanning for various reasons over a seven month period were classified into two groups. Group 1 was issued with instructions to hydrate properly by fluid intake following tracer injection while subjects of group 2 were instructed not to take any fluids till the scan imaging. Computer based equal regions of interest (ROI) were done; over the mid- femoral diaphysis [bone ROI] and the adjacent soft tissue area [soft tissue ROI]. A bone to soft tissue ratio was obtained for each case [B: ST]. No statistically significant difference was found between the ratios' means in both groups. Hence, we concluded that hydration with fluids following Tc-99m MDP injection has no significant effect on the bone: soft tissue ratio and in turn, the skeletal scintigraphic quality.

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List of Abbreviations

Abbreviation	In Full
BS	Bone scintigraphy
RP	Radionuclidic Purity
G1	Group 1- Positive water intake
G2	Group 2- No water intake
RTH	Radiotherapy
CTH	Chemotherapy
BMI	Body mass index
ROI	Region of interest

Introduction

Bone scintigraphy[BS] is one of the most frequently performed of all radionuclide procedures with wide diverse applications.(1) It stood the test of time. It is quick, relatively inexpensive, widely available, and exquisitely sensitive and is invaluable in the diagnostic evaluation of numerous pathologic conditions. The procedure is performed with technetium-99m–labeled diphosphonates. These compounds accumulate rapidly in bone, and by 2–6 hours after injection, about 50% of the injected dose is in the skeletal system. The uptake mechanisms of diphosphonates have not been completely clear. Presumably they are adsorbed to the mineral phase of bone, with relatively little binding to the organic phase. The degree of radiotracer uptake depends primarily on two factors: blood flow and, perhaps more importantly, the rate of new bone formation.(2, 3)

Radionuclide bone imaging is not specific, but its excellent sensitivity makes it useful in screening for many pathologic conditions. Moreover, some conditions that are not clearly depicted on anatomic images can be diagnosed with bone scintigraphy.BS will likely remain a popular and important imaging modality for years to come.(4)

Bone imaging continues to be the second greatest-volume nuclear imaging procedure, offering the advantage of total body examination, low cost, and high sensitivity. Its power rests in the physiological uptake and pathophysiologic behavior of technetium-99m (Tc-99m) diphosphonates. It is a versatile tool that can image

malignant and benign processes and can image the entire skeleton at reasonable cost. Therefore, BS remains popular despite technological advances in magnetic resonance imaging (MRI), computed tomography (CT), and positron emission tomography (PET). Its major drawback of this investigation is its low specificity. Numerous benign processes (e.g., arthritis) cause increased radiotracer uptake by increasing blood flow and osteogenic activity. Often the location and patterns of abnormalities can guide interpretation. However, it is essential to know the patient's history, understand when radiographic correlation is necessary, and know how to use it.(5)

Although protocols vary among institutions, imaging is typically performed 2–6 hours after intravenous administration of 740–925 MBq(20–25 mCi) of Tc-99m–labeled diphosphonates. A gamma camera equipped with a low-energy, high-resolution collimator will yield the highest-resolution images. Additional anterior and posterior whole-body images are often obtained as needed.(6)

Although CT, MRI, PET, SPECT, and SPECT/CT have developed into excellent tools for evaluating patients with suspected bony pathology, planar bone imaging has stood the test of time. More than 3,450,000 bone scans were performed in the United States in 2005. Nearly all bone scans performed still use planar images as their foundation, with SPECT adding complementary information.(1)

Aim of the work

To investigate the influence of patient's hydration or non-hydration following radiopharmaceutical administration on the quality of Tc^{99m}MDP bone scintigraphic images.

Review
of Literature

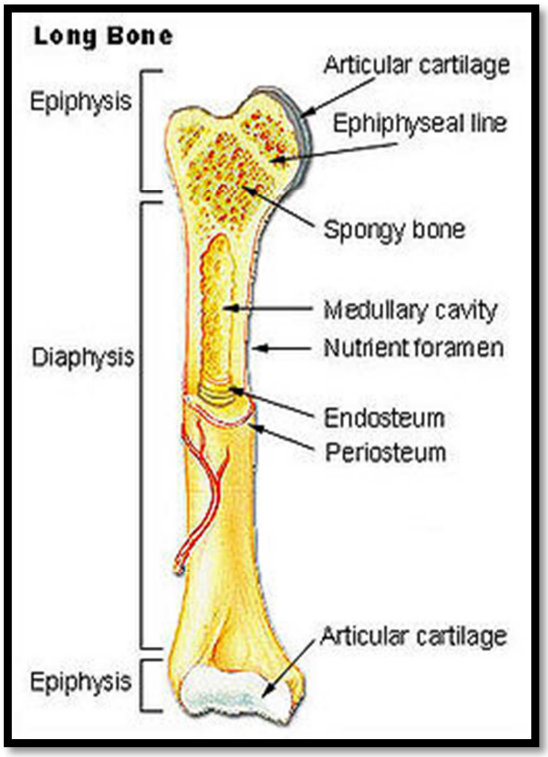
Bone Anatomy

A typical long bone consists of the following parts: the diaphysis (the shaft of the bone), the epiphysis (the bone located from the growth plate to the articular surface), the metaphysis (the region where the diaphysis joins the epiphysis), the articular cartilage, the periosteum (fibrous covering around the surface of bone), the medullary cavity and the endosteum (a layer of progenitor cells and osteoblasts that lines the medullary cavity and also contains scattered osteoclasts).(7)

Bone is an organ consisting mainly of minerals (roughly 65%) and organic matrix (35%), being the storehouse for the body's calcium, phosphorus, sodium, magnesium and calcium. Mineralized bone is called osteoid. The organic part of matrix is mainly composed of type I collagen (90–95%), and also contains various growth factors (like cytokines and growth factors) that play a role in modulating the bone turnover[figure 1].(8)

The skeleton is a living, active organ that changes during the normal physiological process of growth and remodeling and in response to pathologic processes.(9)

The bone-forming cells include the osteoprogenitor cells, osteoblasts and osteocytes, whereas the bone re-absorbing cells are the osteoclasts.(10)



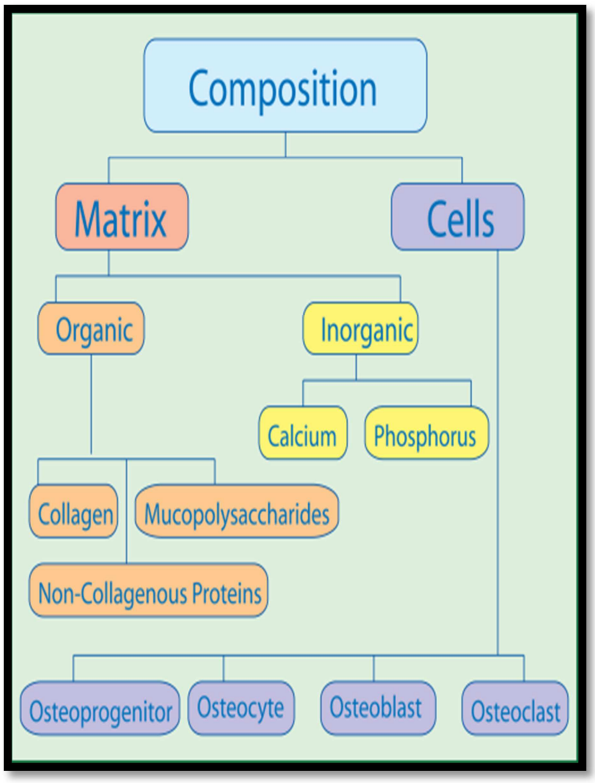


Figure 1: Simple Anatomical Illustration of a Long Bone and Normal Bone Composition(7)

Bone Scintigraphy

The skeleton is a living, active, constantly changing organ that changes during the normal physiological process of growth and remodeling and in response to pathologic processes.(9) Bone is constantly changing, with an ongoing level of bone resorption (osteoclastic) and bone formation (osteoblastic) at an attempt to self-repair. Osteoblasts form an osteoid matrix that is later mineralized with hydroxyapatite crystals. The mineralized bone matrix contains numerous growth factors that are released during the process of repair, stimulating osteoblasts to form new bone. Systemic factors, such as the parathyroid hormone, and local factors such as cytokines, promote osteoclastic activity[Figure 1].(9)

Tc-99m diphosphonates bind to the hydroxyapatite crystals in proportion to local blood flow and osteoblastic activity and are therefore markers of bone turnover and bone perfusion.(10)They rapidly localize to bone and clear quickly from background, making them favorable for imaging. Even a 5% change in bone turnover can be detected on bone imaging, whereas on radiographs and CT, 40%-50% of mineral must be lost to detect lucency within the bone.(11-13)Therefore, bone imaging can often detect disease- related dysfunction before anatomic changes are appreciated.(14)

Bone scan is sensitive for both primarily osteoblastic and primarily osteolytic processes. Even a tiny amount of bony destruction causes an intensely osteoblastic healing process that surrounds the lytic area. Fractures, osteomyelitis and lytic metastases

are all examples of bony destruction that can allow early detection of the associated healing process on bone imaging.(5)

Sometimes pathologic bone image findings are characterized by "cold" areas. This may be caused by very aggressive processes (i.e. bone metastasis), indolent processes that induce little healing reaction (i.e. Brodie's abscess, indolent bony metastatic disease, plasmacytoma/neuroblastoma), or disruption of blood flow (i.e. cold Osteomyelitis, bone infarcts, avascular necrosis, frostbite or gangrene.(15)

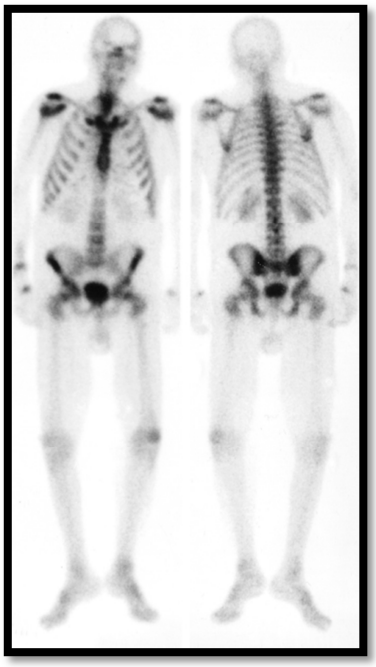


Figure 2: Essentially Normal Tc-99m methylene diphosphonate (MDP) Whole Body Bone Scan. A high level of anatomic detail can be visualized. Some areas of increased uptake are normally seen in the adult including activity in the joints.(11)