Diagnostic performance of SPECT/CT versus diffusion-weighted MRI in characterization of equivocal osseous lesions detected by bone scan

Thesis Submitted for Partial Fulfillment of Master Degree in Nuclear Medicine

By

Maha Khalil Mahmoud Khalil

(MB BCH)

South Egypt Cancer Institute - Assiut University

Supervised by

Prof. Dr. Ahmed Abdel-Samie Kandeel

Professor of Nuclear Medicine

Faculty of Medicine-Cairo University

Ass.Prof. Dr.Haisam Ahmed Samy Aly Atta

Assistant Professor of Diagnostic Radiology

South Egypt Cancer Institute- Assiut University

Faculty of medicine
Cairo University
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ABSTRACT

Objectives: To evaluate the diagnostic performance of ^{99m}Tc-MDP bone scintigraphy using SPECT/CT in comparison to diffusion-weighted (DW) MRI in the characterization of equivocal osseous lesions detected on planar bone scintigraphy.

Methods: This ongoing prospective study recruited 31 cancer patients referred for bone scintigraphy (staging/restaging/follow-up) with their planar whole body scan showing equivocal osseous lesion. Every patient further underwent SPECT/CT& DW-MRI within two weeks. Studies were read independently by two experienced nuclear medicine physicians and one experienced radiologist on a 5-point score: (score 1 = benign, score 2 = likely benign, score 3 = equivocal, score 4 = likely malignant and score 5 = malignant). The final diagnosis of disease status was made on the basis of subsequent clinical/imaging follow-up for at least 6 months.

Results: Of the 31 patients evaluated, only 9 (29%) proved to have osseous metastases, 20 (64%) were disease free and 2 (6%) were excluded from the study. SPECT/CT & DW-MRI had sensitivity, specificity, negative predictive value, positive predictive value, and accuracy of 67% vs. 67%, 90% vs. 75%, 86% vs. 83%, 75% vs. 55% and 83% vs. 72%; respectively. Both modalities were true positive in 4, true negative in 14, false positive in 1 and false negative in 1 patient(s). No statistically significant difference noted in sensitivity, specificity or accuracy.

Conclusions: Bone scintigraphy using SPECT/CT is not superior to DW-MRI in characterization of equivocal osseous lesions detected on planar scans. Further work is ongoing to identify the exact role of each modality in different tumor types.

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ABBREVIATIONS

ADC	Apparent diffusion coefficient
AUC	Area under the curve
BS	Bone scintigraphy
CT	Computed tomography
CTDIvol	Dose parameters volume weighted CT dose index
CTR	Chemotherapy
DLP	Dose length product
DV	Dorsal vertebra
DWI	Diffusion weighted imaging
DWI-EP	Diffusion weighted imaging echo planar
DW-MRI	Diffusion weighted magnetic resonance imaging
FOV	Field of view
FN	False negative
FN	False positive
HASTE	Half-Fourier acquisition single shot turbo spin echo
Kev	Kilo-electron volt
kVp	Peak kilo voltage
MAs	Milli ambers
MBq	Mega Becquerel
mCi	Millicurie
MSEPI	Multi-shot echo-planar imaging
msv	Milli sievert
MTC	Medullary thyroid cancer
NaTco4	Sodium pertecntate

NPV	Negative predictive value
PPV	Positive predictive value
RARE	Rapid acquisition with relaxation enhancement
ROC	Receiver operating characteristic
ROI	Region of interest
RTH	Radiotherapy
SNR	Single to noise ratio
SPECT	Single photon emission computed tomography
SS-EPI	Single shot echo planar imaging
SS-FSE	Single shot fast spin echo
STIR	Short-tau inversion recovery
T	Tesla
T1 WI	T1 weighted image
T2 WI	T2 weighted image
Tc^{99m} -MDP	Technetium-99m methylene diphosphonate
TIRM	Turbo inversion recovery magnitude
TN	True negative
TP	True positive
TSE	Turbo spin echo

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Introduction & Aim of work

Introduction

Bone is one of the most common sites of distant metastasis in cancer patients, apart from the lung and liver[1]. Most bone metastases result from hematogenous dissemination of cancer cells. Various anatomical and functional imaging modalities are used for detecting and characterizing bone metastasis. Among them, bone scintigraphy, commonly performed with ^{99m}technetium methylene diphosphonate (^{99m}Tc-MDP), is a widely used procedure that provides a whole-body skeletal survey at a relatively low cost and is usually the initial imaging modality for the assessment of bone metastases[2].

Numerous reports emphasize the high sensitivity of bone scintigraphy in the diagnosis of osseous metastases. However, bone scintigraphy lacks specificity due to the known increased blood flow and metabolic reaction of the bone to a variety of disease processes, including osteoarthritis, trauma, and inflammation[3].

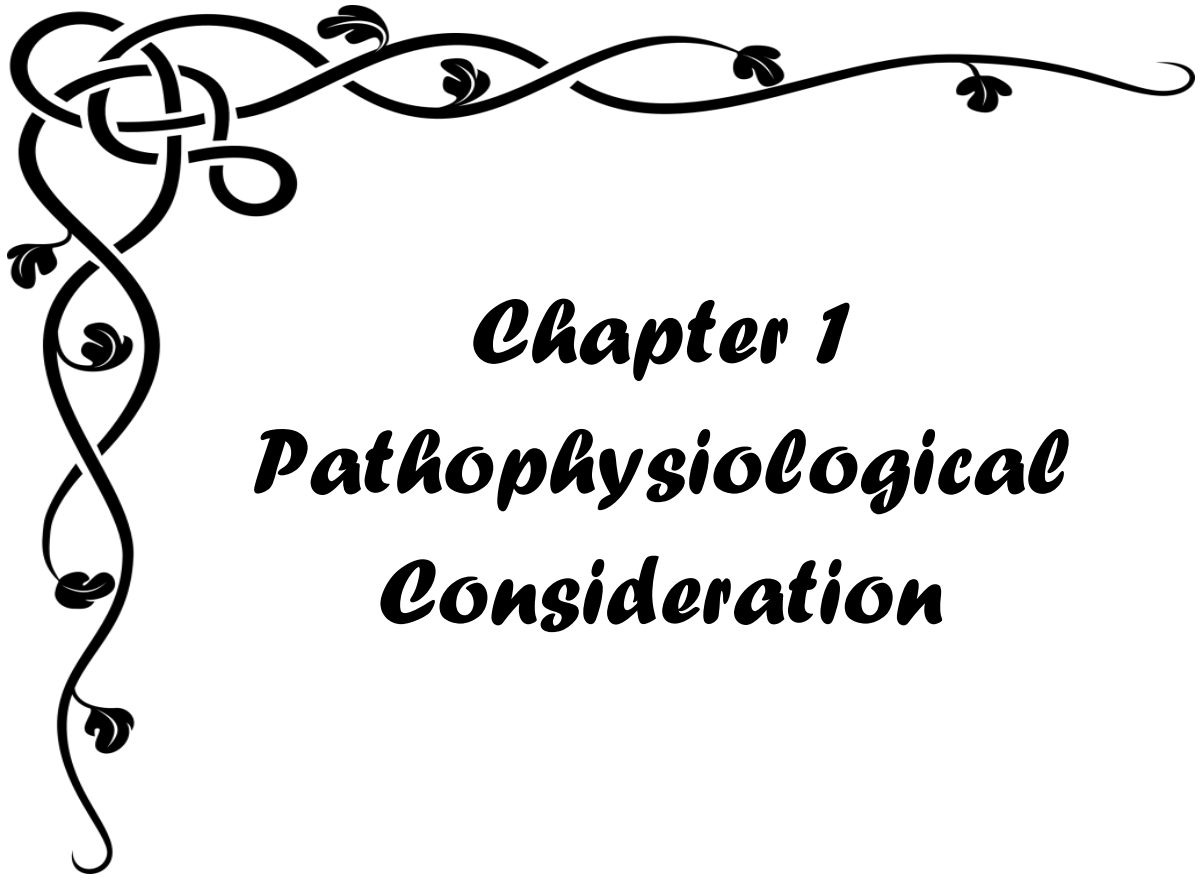
Recently, state of the art hybrid SPECT-CT systems that have become available combine both tomographic scintigraphy and CT, producing a unique combination of the functional and anatomical sets of data[4]. These systems allow the field of view of the CT scan to be adapted to line up with the SPECT findings. SPECT-CT has been shown to be useful for various indications and for different regions[5].

Diffusion-weighted MRI (DWI) is another rapidly evolving functional imaging modality that can be used to evaluate oncologic and non-oncologic lesions throughout the body. DWI is sensitive to the random (Brownian) motion of water molecules. In biologic tissue, the presence of impeding barriers *(e.g., cell membranes, fibers, and*

macromolecules) interferes with the free displacement (diffusion) of water molecules. Consequently, the signal intensity in DWI depends on the separation and permeability of these impeding boundaries[6]. Pathologic processes that alter the physical nature of the restricting barriers in biologic tissue affect the diffusivity of the water molecules, which can be visualized and quantified using DWI. Since tissue water movements are not free but impeded, tissue diffusivity is often termed the apparent diffusion coefficient (ADC; units: μm^2 /s or $\times 10^{-3}$ mm^2 /s). DWI has been extensively evaluated for its role in the assessment of vertebral compression fractures, specifically for differentiating between benign and malignant causes[6].

Aim of The Work

The aim of this prospective study is to compare between SPECT/CT and DW-MRI in characterization of equivocal osseous lesions detected by conventional planar bone scan.

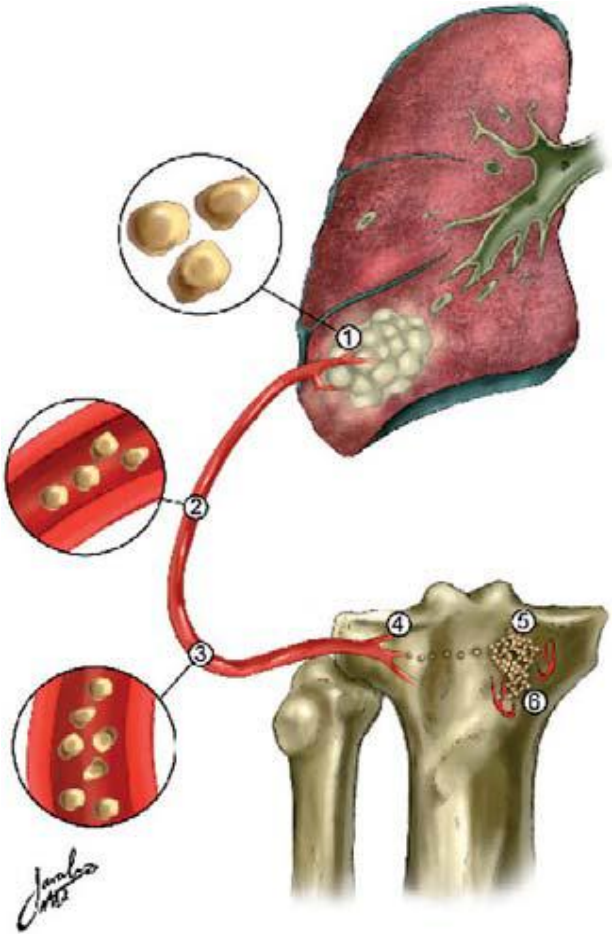


Chapter 1
Pathophysiological Consideration

Metastatic Bone Disease

Metastasis means "the transfer of disease from one organ or part to another not directly connected with it"[7]. In general, several events are required for the metastatic spread of tumors **(Fig.1)**. The sequence of these events is as follows:

1. Neoplastic cells separate from primary tumors.
2. They gain access to an efficient lymphatic channel or blood capillary.
3. They survive during transport.
4. They attach to the endothelium of a distant capillary bed.
5. They exit from the vessel.
6. They develop a supporting blood supply for the cells at the new site.



(Fig. 1) Events required for metastatic spread:
1. **Separation of cells from primary**
2. **Access of separated cells to an efficient lymph channel or blood cap;**
3. **Survival of cells during transport;**
4. **Successful attachment of cells to the endothelium of a distant cap bed;**
5. **Exit of cells from vessel at new site.**
6. **Successful development of a supporting blood supply[7]**