Diagnosis and Monitoring of Breast cancer – Relevance of Nuclear Medicine.

Dr Jawa, ZM
MBBS, MSc, FMCR, FCNP, FEBNM
Senior Consultant Nuclear Medicine Physician
European Board Certified in Nuclear Medicine
Address

• Screening/Diagnosis
  Tc-99m MIBI Scintimammography
  Tc-99m nanocolloid Sentinel node mapping

• Staging
  SPECT, Tc-99m MDP
  PET-CT, F-18 FDG

• Follow-up (Remission, Relapse, Recurrence)

• Bone pain Palliation, Sm-153

• Monitoring drug toxicity; MUGA & Renography
Nuclear Medicine: Physiology

1. SPECT; TC99m MDP bone scan
2. PET; FDG18 scan

New trends (anatomy and physiology)

SPECT-CT, PET-CT, PET-MRI
Gamma camera; SPECT / PET
Nuclear Medicine in Breast Cancer

1. Screening and Detection
2. Diagnosis; (Staging and Re-staging)
3. Therapy (still on trials)
4. Follow-up (remission, relapse, reoccurrence)
5. Palliation (Bone pain metastases)
6. Monitoring toxic effects of chemotherapy
Tumors

- Metabolically active tissues – many similar properties as inflammation
  - Increased vascularization
  - Increased capillary permeability
  - Newly proliferated capillaries
  - Increased blood flow
  - Metabolically active cells
  - Increased energy demand
Tumor cells

- High density of some common receptors
- Expression of several specific receptors
- Expression of some specific tumor antigens
- All these properties could be used for imaging and therapy
Screening/detection
Scintimammography
Scintimammography
NORMAL SCINTIMAMMOGRAPHY
BREAST CA (L) WITH Tc 99m-MDP
BREAST CA (R) IN SMG
SMG & BONE SCAN (no meta)
Sentinile node mapping

Tracer Administration in Breast Cancer

Intra-or subcutaneous

Peri-or subareolar

SUPERFICIAL

Intratumoral

Peritumoral

DEEP
Why lymphoscintigraphy in sentinel node procedures?

- To identify nodes at risk for metastases
- To indicate number of sentinel nodes
- To distinguish between 1\textsuperscript{st} and 2\textsuperscript{nd} tier nodes
- To identify nodes in unpredictable positions
- To mark position on the skin
Radioisotope +/- Blue Dye
Basic principles

- 80 – 100 MBq Tc-99m nanocolloid
- Volume 0.1 ml in 4 syringes
- Injected in subareolar space
- Dynamic images for 20 minutes
- Static images up to 3 hours
- Position marked on skin
- Surgery – up to 24 hrs later with gamma probe and blue dye localisation
Direct drainage
Direct drainage
Staging
Bone scan

- Tc-99m MDP
- Very high Sensitivity but low Specificity
- Whole body
- Cheap and relatively affordable
Report

Procedure: Whole body bone scan
Radiopharmaceuticals: Tc-99m MDP 500MBq
There is normal biodistribution of radiotracer in the entire skeleton. The kidneys demonstrated good excretion.

CONCLUSION
Normal bone scan with no evidence of skeletal metastases

Dr ZM Jawa MBBS, FMCR, FCNP, FEBNM
Consultant Nuclear Medicine Physician
Patient name: A
Date of birth: 5/3/1945
Date of acq.: 3/7/2010 3:18:25 PM
Patient ID: 034985
Study ID: TB100683

Report

Procedure: Whole body bone scan.
Radiopharmaceuticals: Tc-99m MDP 594 MBq

There are multiple uptake of varying sizes and intensities in keeping with metastases involving the following regions:
1. Ribs bilateral
2. Thoracic and lumbar spines
3. Left inferior pubic rami
4. Proximal humerus and femur bilaterally
   The rest of the skeleton shows normal biodistribution of radioactivity.
   There is evidence of right sided hydronephrosis.

CONCLUSION
Findings are consistent with multiple skeletal metastases mainly involving the axail skeleton.

Dr Jawa, ZM MBBS, FMCN, FCNP
Consultant Nuclear Medicine Physician
Re-staging and Follow-up
**Whole Body Scan**

**Patient name:** [Redacted]
**Date of birth:** 4/30/1939
**Date of acq.:** 4/26/2008 12:41:22 PM

**Patient ID:** 095409
**Study ID:** BO080039

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**Report**

Procedure: Whole body bone scan (FOLLOW-UP).
Radiopharmaceuticals: Tc-99m MDP 679MBq.

When compared to the previous bone scan of 26/4/08:
1. Newer lesions are noted in the skull, ribs bilaterally, right humerus, entire pelvis and both femurs.
2. The previous lesions have increased in sizes and intensities.
The kidneys are not visualized giving an appearance of 'supper scan'.

**CONCLUSION**

Widespread skeletal metastases with worsening of disease when compared to previous scan.

Dr Jawa Z M
Patient name: [Redacted]
Date of birth: 1/26/1977
Date of acq.: 3/6/2009 1:45:06 PM

Patient ID: 303670
Study ID: TB090186

Procedure: Whole body bone scan (FOLLOW-UP)
Radiopharmaceuticals: Tc-99m MDP 600MBq
When compared to the previous bone scan do on 6/3/09:
1. No new lesion is seen in the current study.
2. There is almost complete disappearance of the metastatic lesion in the femurs, ribs, skull and humerus.
3. Lesions in the spine are still present but have reduced significantly.
4. The rest of the skeleton remain essentially unchanged.

The kidneys are visualised and they show good excretion.

CONCLUSION
There is a dramatic improvement in skeletal metastases and evidence of non-progression

Dr. Jawa, ZM MBBS, FMCR, FCNP
Consultant Nuclear Medicine Physician
Whole Body Scan

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Dr Jawa Z M
PET-CT

- Molecular imaging with FDG 18
- Very sensitive and specific
- Differentiate active disease clearly from fibrosis
- Monitoring response of therapy

- Expensive
Treatment Response Assessment in Breast Cancer

Lack of treatment response documented by PET after chemotherapy
Palliation
Sm153-EDTMP
And Bone Metastases from Breast Cancer
Which Cancers?

- Breast (70%) ⇒ 40% osteoblastic
- Prostate (70%) ⇒ 80% osteoblastic
- Lung (30%) ⇒ 10% osteoblastic
- Thyroid (50%)
- Kidney-Bladder (25%)
- Stomach
- Ovary

Prostate + Breast + Lung = 45% of all cancers.
Medical Perspective on Skeletal Metastases

• Source of considerable morbidity: pain, hypercalcemia, spinal cord compression, pathologic fracture, marrow infiltration.

• Pain initially mild to moderate, progressively increasing, becoming multifocal and refractory to various treatments.

Causes of pain from bone metastasis

- Indirect stimulation through release of histamine, prostaglandins, cytokines.
- Stimulation of periosteal nerve endings due to direct neoplastic involvement.
- Increased intramedullary pressure.
- Collapse of bone structure $\Rightarrow$ fracture.
- Radicular compression (spine).
Therapy with Sm-153 EDTMP

• Primary goal: palliation of bone pain.

• Consistent bone pain palliation (partial + complete) achieved in 60%-75% of patients and lasting weeks to months.

• Multifactorial mechanism(s) of bone pain palliation: mostly through reduced release of cytokines.
$^{153}\text{Sm-EDTMP}$

- Beta-particle emission (energy = 810 keV)
- Gamma radiation emission (energy = 103 keV), used for biodistribution and dosimetric measures.
- Radiation absorbed dose of approximately 7 cGy/mCi in normal bone and 42 cGy/mCi in osteoblastic bone lesions.
$^{99m}$Tc-MDP

blood capillary

interstitial space

peri-endo-osteal membrane

non-mineralized osteoid

amorphous Ca phosphate

hydroxyapatite crystals
Whole-body Bone scan with Tc-99m MDP before treatment (A) and with Sm-153 EDTMP a few hours after treatment (B).

*bone-lesion/normal-bone ratios : 3-7/1*

*Coronado et al. Clin Nucl Med 2006*
Metastatic Breast cancer

September 2010

Post-therapy
$^{153}\text{Sm}}$-EDTMP

February 2011

$^{99m}\text{Tc}}$-MDP
Metastatic Breast cancer

August 2011

Baseline

January 2012

Follow-up

$^{153}\text{Sm-EDTMP}$
Monitoring and evaluation of chemotherapy toxicity

- MUGA scan; cardiotoxicity
- Renography: Renal toxicity
Future

• Molecular imaging
Future.....Target Specific Radiopharmaceuticals

Targeting Molecules:
- Peptides
- Peptide mimics
- Nucleotides
- Small molecules
- Antibodies

Targets (unique features):
- Cell surface receptors
- Transport mechanisms
- Proteins
- DNA/RNA

Bifunctional Chelate
Targeting Molecule
Radionuclide
Linker
Biological target
Biological Target Design

- Target a specific biological function
18F-Labeled HER2-Affibody

Kramer-Marek et al., Eur J Nucl Med Mol Imag 2008; 35:1008-1018; NIH, Bethesda, MD
Conclusion

• Screening
• Diagnosis
• Staging
• Follow-up (Remission, Relapse, Recurrence)
• Bone pain Palliation, Sm-153
NUCLEAR MEDICINE

Powerful diagnostic/therapy tool, Robust and well Validated

Clinical problem

Radiopharmaceuticals
Instrumentation

Good clinical history & exams. Radiological modalities, laboratory tests
Thank you