Advanced breast molecular imaging
MBI and PET

Arison Tower

Lis Maternity center

Cardiovascular center

Prof. Einat Even-Sapir, MD, PhD
Tel Aviv Sourasky Medical Center,
Sackler School of Medicine. Tel Aviv , ISRAEL

Imaging of the breast- goals

- ***Screening for breast cancer in patients with unknown cancer***

  Purpose:

  - Early detection of cancer

  -Differentiating between clinical relevant lesions and those of no clinical relevance

- ***Personalized medicine in patients with breast cancer***

  Purpose:

  -Assessing the extent of the disease in the breast

  -Monitoring response to therapy (neo-adjuvant, viability)

  -Detection of recurrence

  -Ruling out disease in the contralateral breast

Breast imaging -concept

-Looking at the architecture of the breast

-<u>Functional breast imaging</u>

Detection of breast abnormality based on the altered characteristics of the tissue rather than its altered morphology

Gamma-emitting imaging

Positron emitting imaging

Types of systems for gamma emitting tracers

- Breast Specific Gamma Imaging (BSGI)

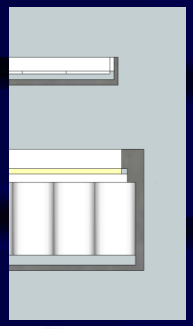
multicrystal **NaI**-based gamma camera

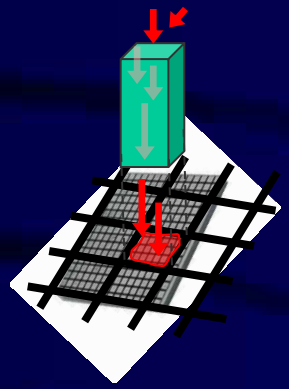
- Molecular Breast Imaging (MBI)

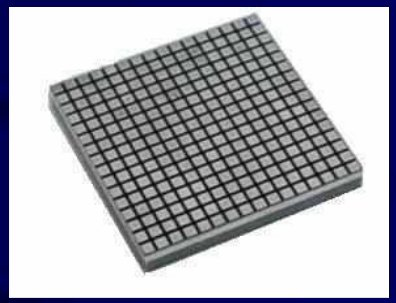
Dual-headed camera with semiconductor (cadmium zinc telluride - **CZT**) detectors.

Discovery* NM750b with CZT technology

- **Improved spatial resolution** - collimator is precisely matched to individual detector pixels
- Up to three times the sensitivity of conventional nuclear detectors







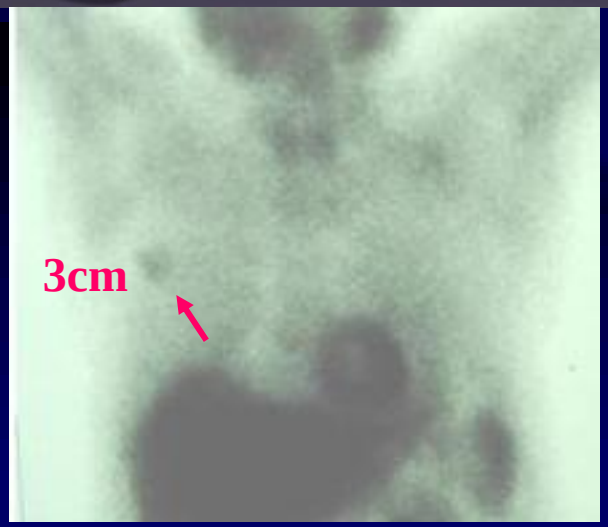
CZT

ROUTINE DETECTOR

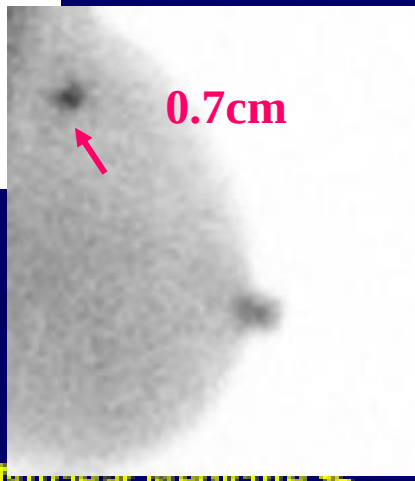
General Electric Company

The importance of organ-specific camera

General purpose gamma camera



Camera dedicated for breast imaging (MBI)



Functional breast imaging

Gamma-emitting imaging

Tracers:

"on the shelf tracers"

99mTc-sestaMIBI, (Globally) Myoview (not approved in US) .

Intracellular uptake of Myoview/Sestamibi in carcinoma cells is nearly 9 times higher than in normal cells

Molecular Breast Imaging (MBI)
CZT dual-headed system

The Mayo Clinic experience

- Tested in over 2500 women at the Mayo Clinic
- Detecting lesions as small as 3 mm in diameter. Sensitivity to tissue abnormalities diameters of 5 mm - 20 mm is 90%.
- In a study on 936 patients at-risk, sensitivity of mammography alone was 27%, while the sensitivity of combined mammography and MBI was 91%.
- Taking advantage of the physical characteristics of CZT, injection dose of Tc-MIBI can be reduced -> reduction in radiation exposure.
- Dose was routinely reduced from 20mCi to 8 mCi and currently to 4mCi.

Molecular Breast Imaging (MBI)

CZT dual-headed system (Discovery NM750b)

The Tel Aviv experience

Breast radiologists, surgeons and oncologists were asked to send women in whom they felt that additional non-invasive assessment of the breast was clinically indicated

Molecular Breast Imaging (MBI)
Indications coming from clinicians 228 studies

Screening for breast cancer n=72

- Genetic and familial high-risk = 3
- equivocal findings on mammography, US and/or MRI = 46
- Nipple discharge = 4
- Discrepancy between clinical and imaging assessment = 8
- Alternative to other examinations = 6
- equivocal findings at the contralateral breast = 5

Diagnostic imaging of the breast in patients with known cancer n=156

- Assessment of the disease extent = 51
- Baseline prior to neo-adjuvant = 21
- Monitoring response after treatment =41
- Assessing the presence of residual disease after surgery = 16
- Suspected recurrence = 11
- Follow up = 13
- Search for primary in patients with LNs mets = 3

Molecular Breast Imaging (MBI)

CZT dual-headed system

The Tel Aviv experience

Sensitivity of MBI in 64 breasts with tissue diagnosis of malignancy. Sensitivity 88%.

TP N= 58

IDC 27
IDC+DCIS 7
DCIS 4
ILC 3
ILC + LCIS 3
DCIS+ lobular cancerization 2
IDC + ILC 1
IDC + ILC + LCIS 1
LCIS 1
Papillary Ca

FN N= 8

- Small or microscopic disease after neoadjuvant 2
- Low and intermediate grade DCIS 3
- Small breast with tumor in the breast tail 1
- diffuse uptake after delivery masking tumor 2

Note that the cohort is not general screening but complicated cases

Assessing the extent of the disease in newly diagnosed cancer.

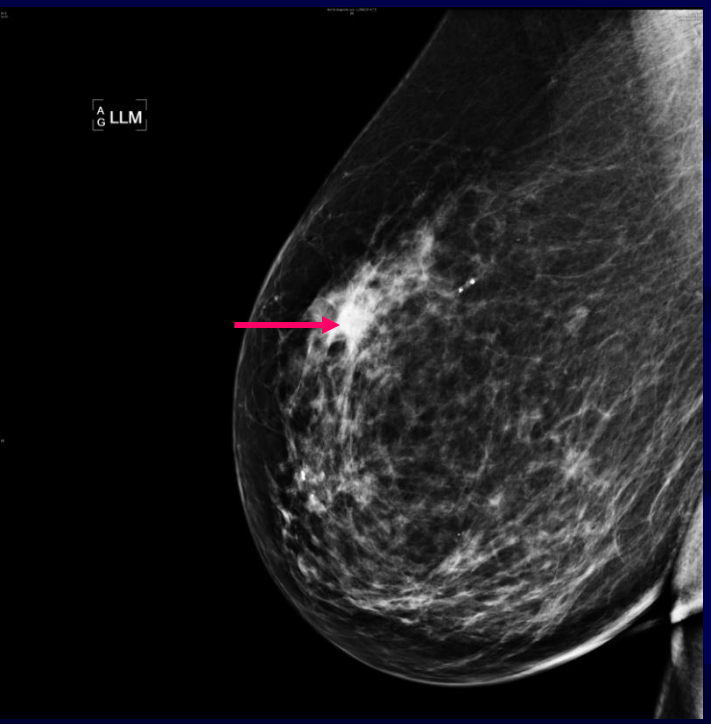
MBI performed as complementary to mammography and us

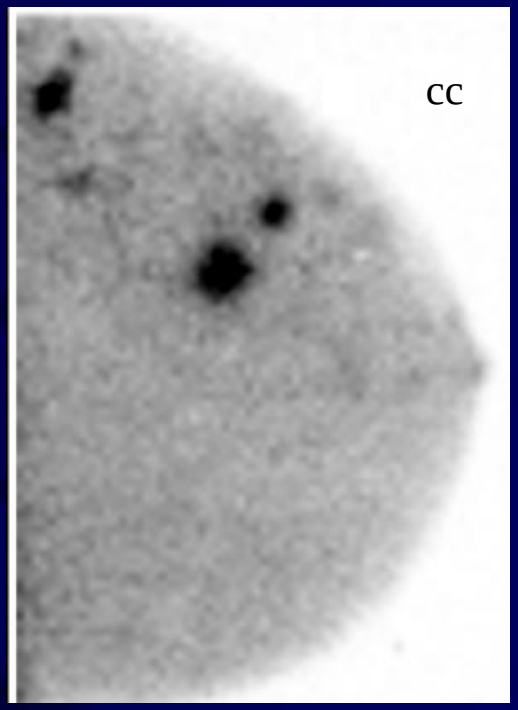
In 15 of the 61 study patients (25%), MBI found tumor sites that were not identified on mammography and US.

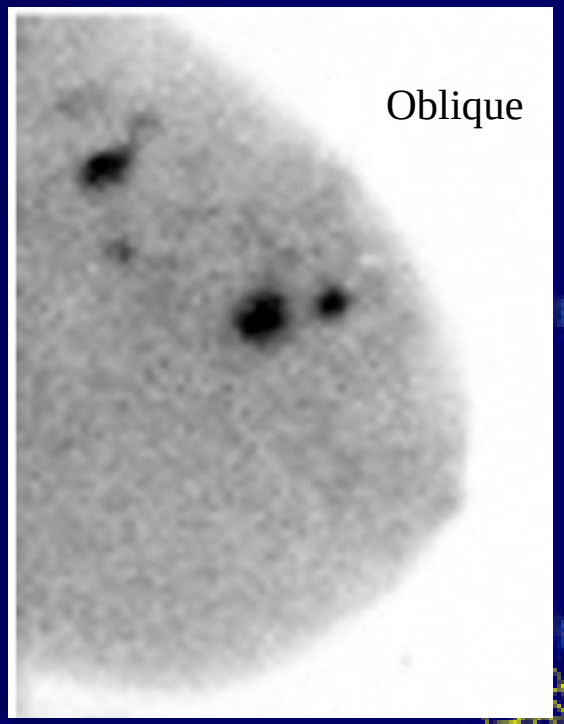
In 7 of the 15 patients composing 11% of the study patients, *multicentric* disease was diagnosed in view of the additional unexpected tumor sites found on MBI.

The change in extent of disease was associated with a change of treatment in (15%) of the patients

Assessing the extent of the disease
prior to surgery







A single lesion on mammography report

IDC on biopsy

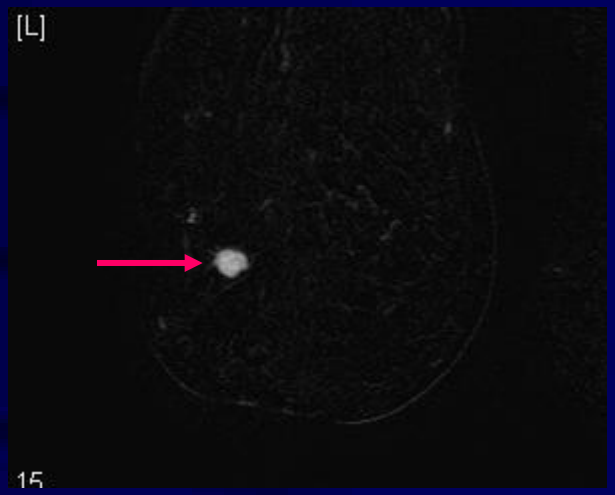
Multiple lesions on MBI

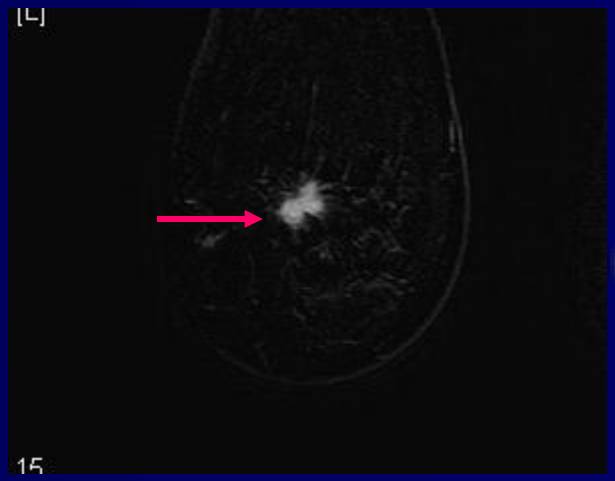
Based on these findings the pt was sent to MRI

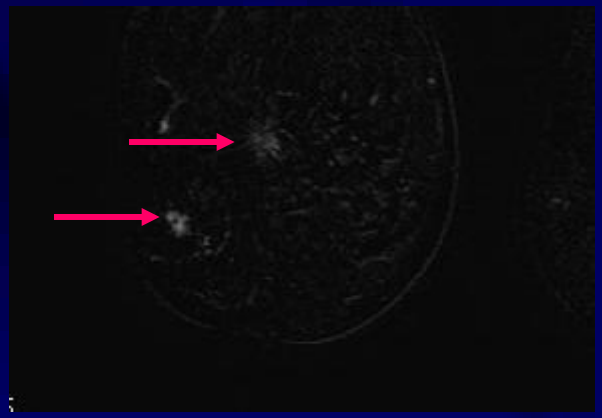
Assessing the extent of the disease

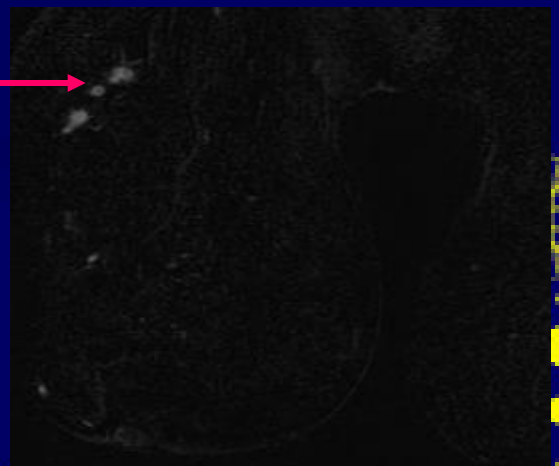
MRI performed post MBI validates diagnosis of a multi-centric disease.

Patient was sent for neo-adjuvant chemotherapy





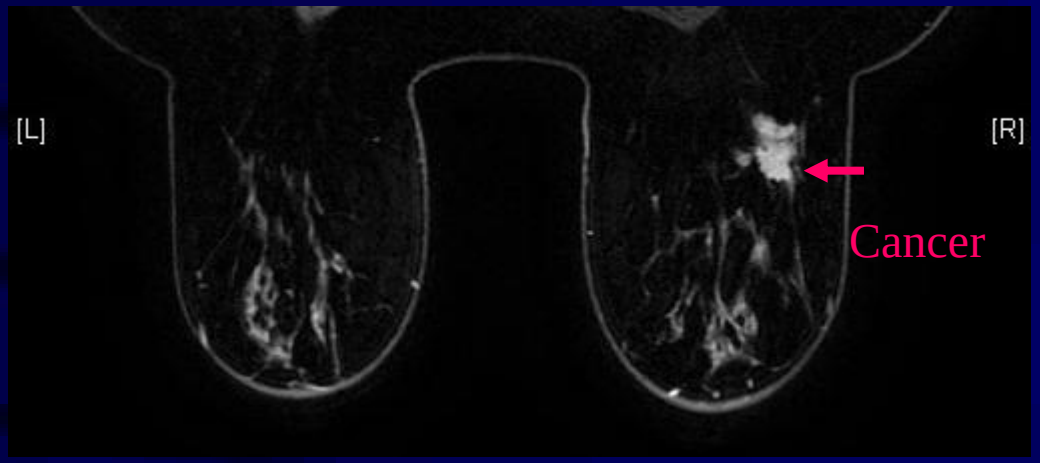


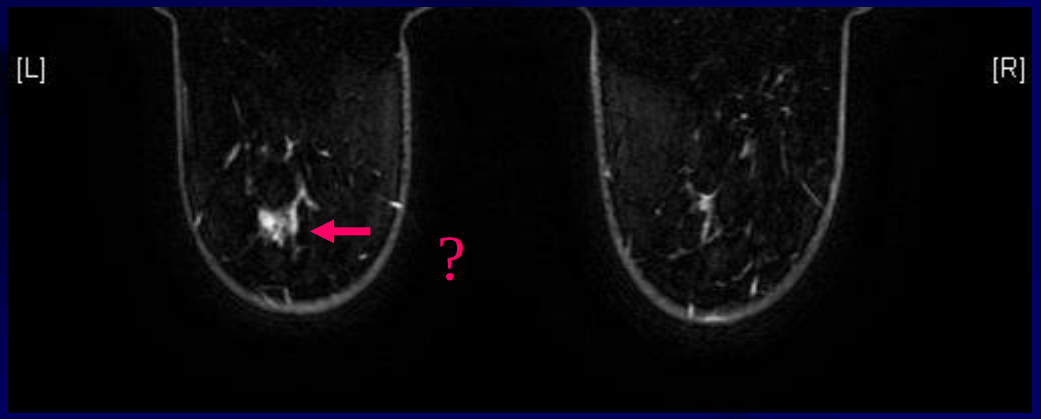


Tel-Aviv Medical Center, Department of Nuclear Medicine

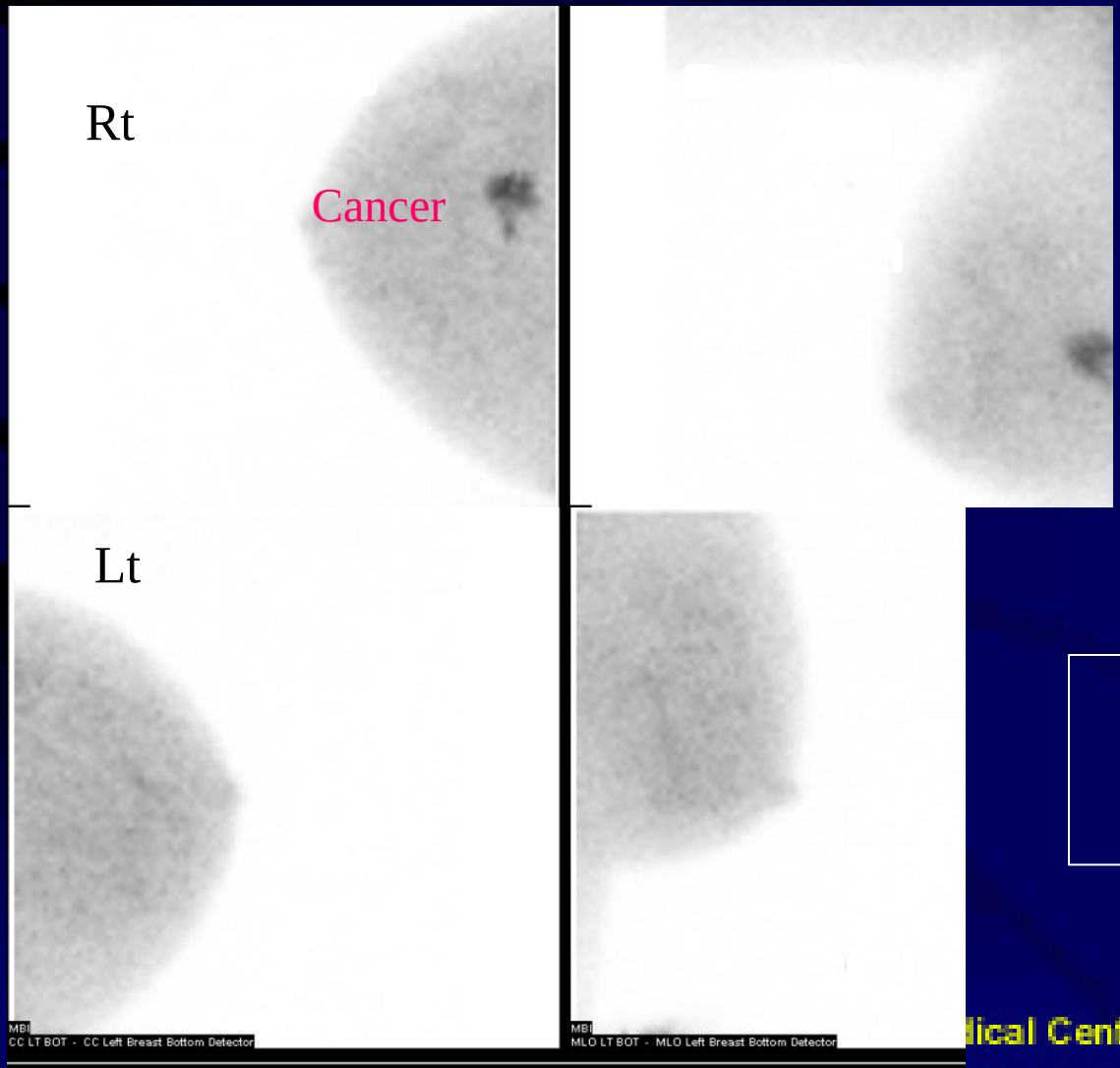
Ruling out disease

Newly diagnosed IDC on the right, suspected lesion on the left





MBI- focal uptake at the primary lesion, no lesions on the left



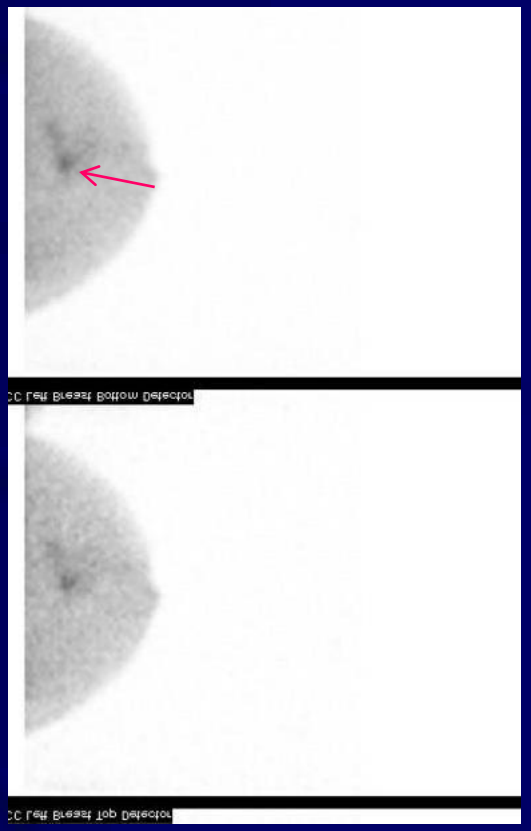
The lesion on the left was biopsied found to be ductal hyperplasia

Monitoring response to neo-adjuvant chemotherapy

A 38-year-old patient before and after neo-adjuvant.
Viable tumor at surgery

Before neo-adjuvant

At completion of neo-adjuvant



The use of MBI after Neo-adjuvant therapy

Comparison with MRI

FN	TP	MBI MRI
1	7	TP
1	2	FN

Sensitivity of MBI - 82%

Sensitivity of MRI – 73%

The use of MBI after Neo-adjuvant therapy

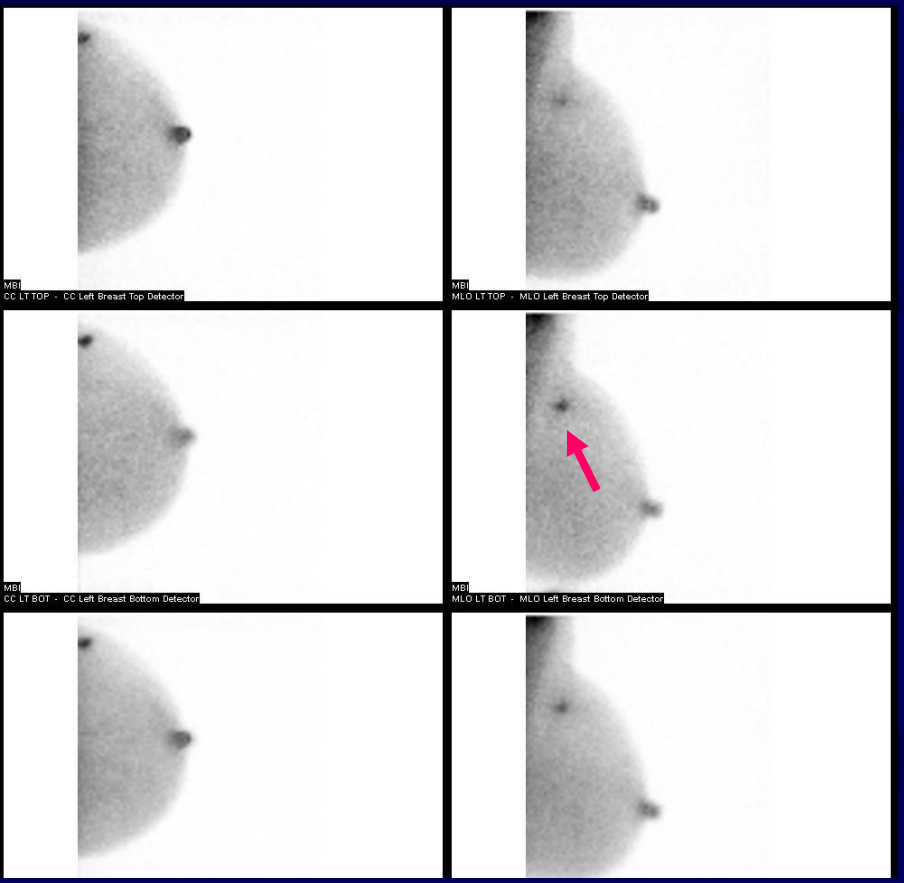
	No of patients	Type of surgery
No change	18	Lumpectomy - 12 Mastectomy - 6
Reassurance of breast conserving approach	9	Lumpectomy – 7 Nipple sparing - 2
Change in plan	1	Mastectomy - 1

Impact of MBI findings post neo-adjuvant on surgery plan and certainty in taking a breast conserving approach

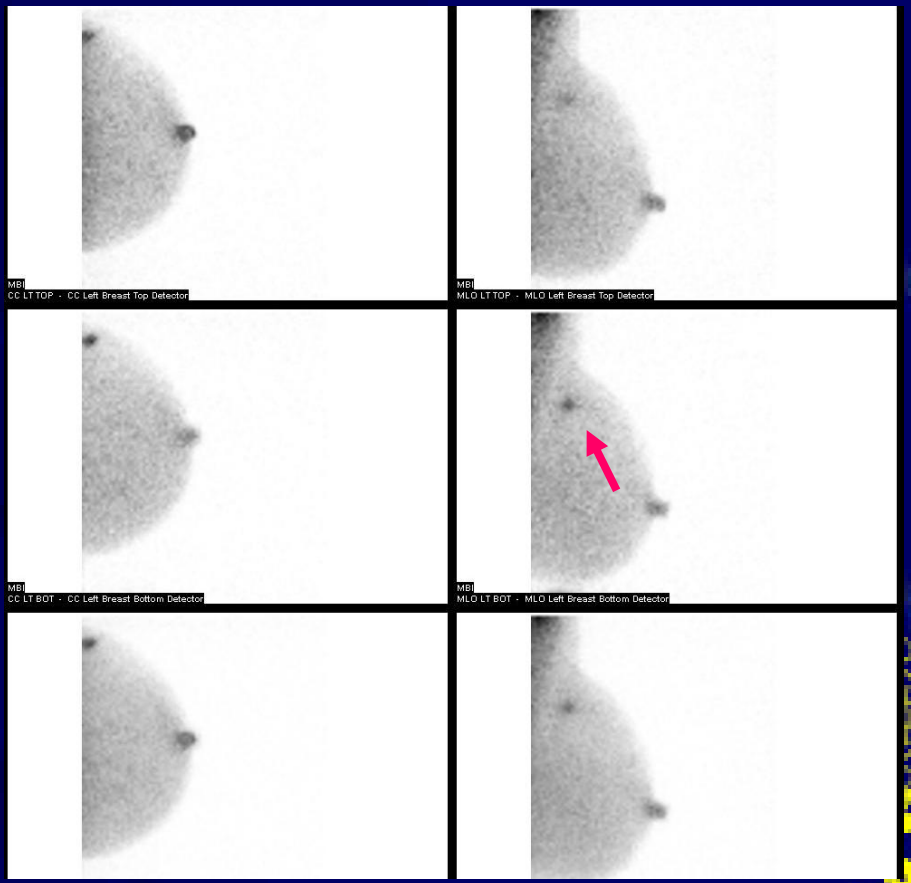
Effective Dose and Dose to the Breast

	Total Effective Dose	Dose to Breast Tissue
Screening Mammography	0.044 rem	0.044 rem
Diagnostic Mammography	0.044 – 0.088 rem	0.044 – 0.088 rem
Total X-ray dose for Diagnostic Patients	**0.088 – 0.,132 rem**	**0.088 – 0.,132 rem**
BSGI	Approximately 0.6 rem	0.02 rem

20mCi vs 8mCi Tc-MIBI 7mm lesion



20mCi



8mCi

F18-Fluorodeoxyglucose PET imaging in Breast Cancer

PEM - from the literature

182 pts:

- For index lesions-

  sensitivity of 92.8% for both PEM and MR.

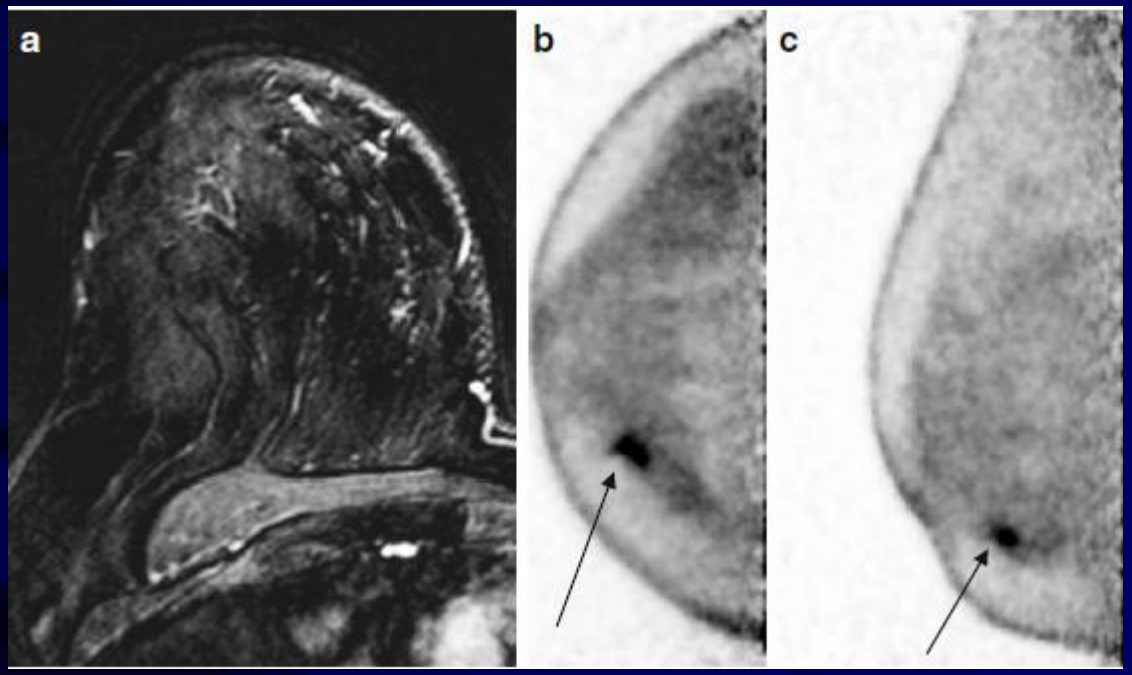
- For unexpected multifocal lesions-

  PEM had sensitivity of 85% and specificity of 74%

  MRI had sensitivity of 98% and specificity of 48%

Schilling et al. Eur J Nucl Med Mol Imaging (2011) 38:23–36

PEM - from the literature

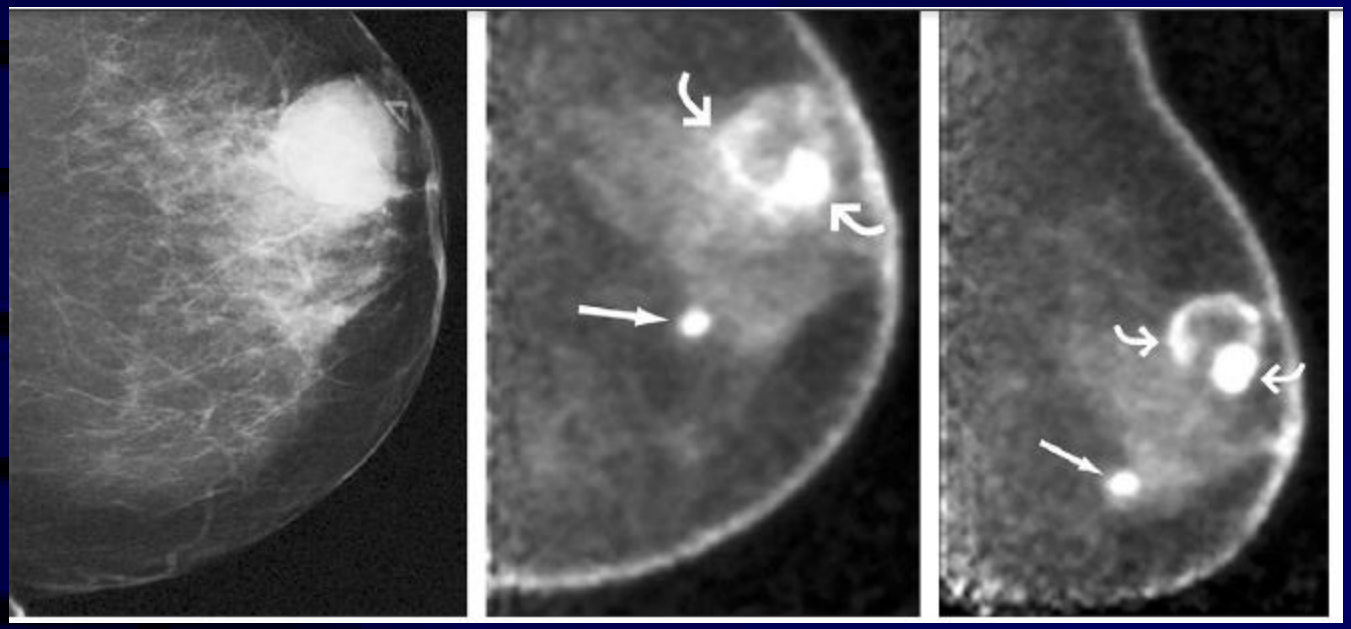


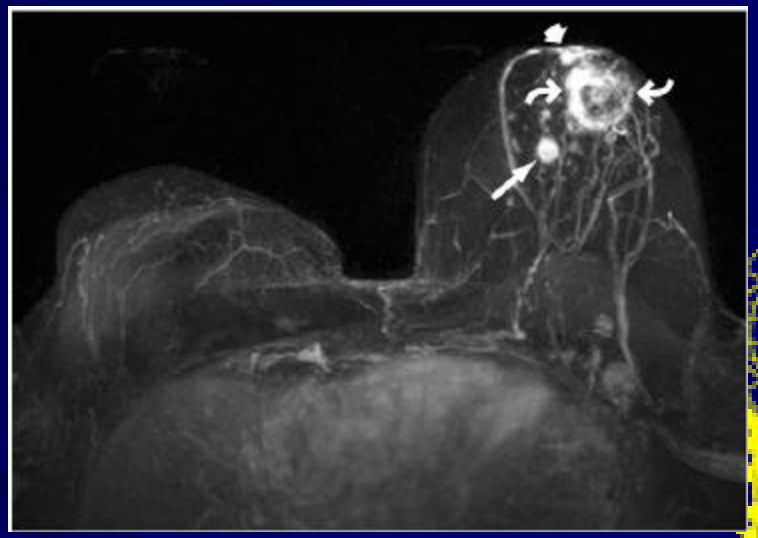
Schilling et al. Eur J Nucl Med Mol Imaging (2011) 38:23–36

388 pts with newly diagnosed cancer, before surgery

- Additional cancers were found in 21% women:
  34% identified with both PEM and MR imaging;
  26% with MR imaging only;
  17% with PEM only;
  8.5% with mammography and ultrasonography.
  15% were missed by all modalities
- Integration of PEM and MR imaging increased cancer detection from 60% to 74%.

Berg et al *Radiology:* 258: 1, 2011





Berg et al *Radiology:* 258: 1, 2011

Functional breast imaging

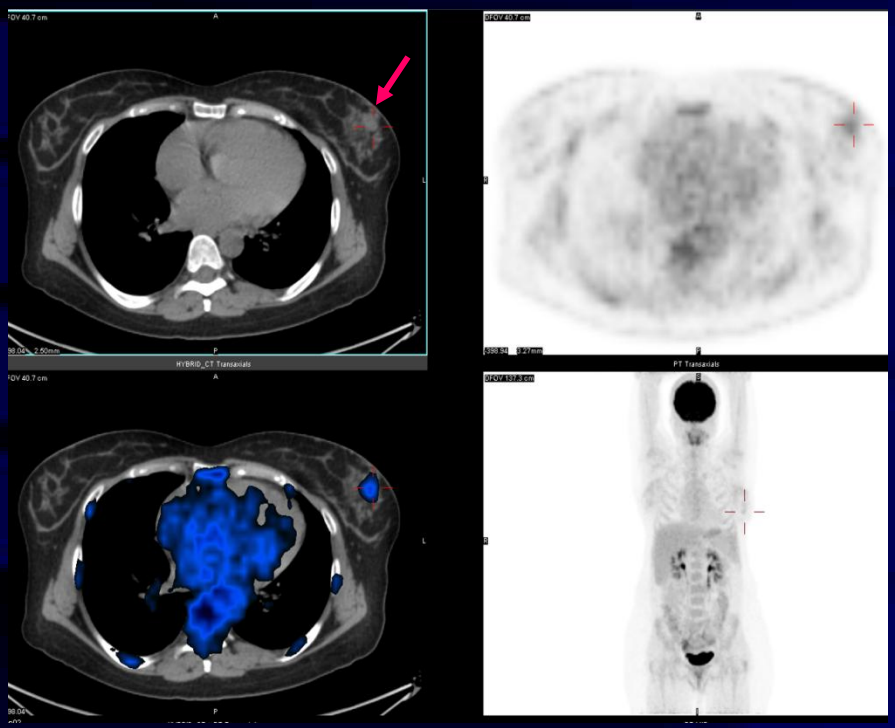
Positron emitting imaging

PET and PEM :

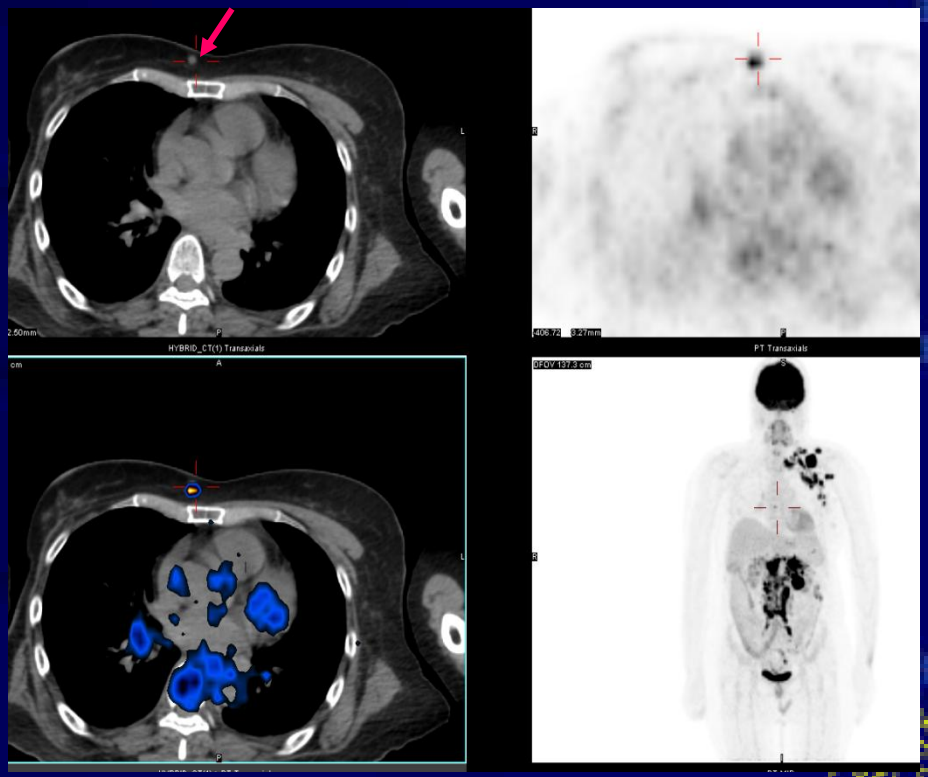
***Tracer*:**

- **FDG-avidity in tumor**
- **need for nearby cyclotron**
- **physiologic uptake in breast parenchyma**
- **control sugar levels and 4h fasting**

Sensitivity of PET in breast cancer depends on the individual tumor's FDG – avidity

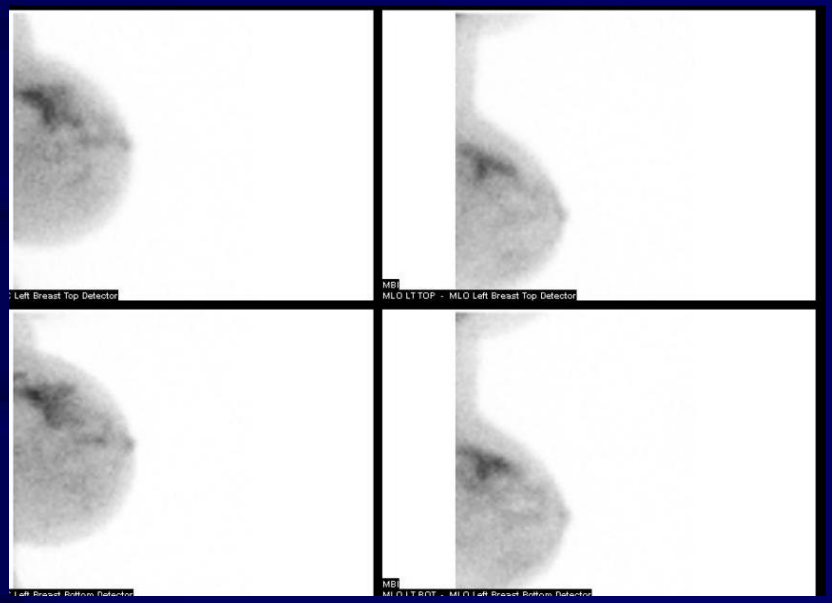


Low-intensity uptake in 1.3 cm lobular carcinoma



High-intensity uptake in 0.4 cm ductal carcinoma

A 47-year-old patient with newly diagnosed lobular carcinoma in the left breast.



^{18}F-FDG- PET: focal low intensity uptake Tu/Bg ratio 1.7

^{99m}Tc-MIBI MBI: extensive region of high uptake Tu/Bg ratio 5

Breast cancer : The goals of whole-body PET-CT

Staging of breast cancer (advanced stage):

Nodal staging

Remote metastases

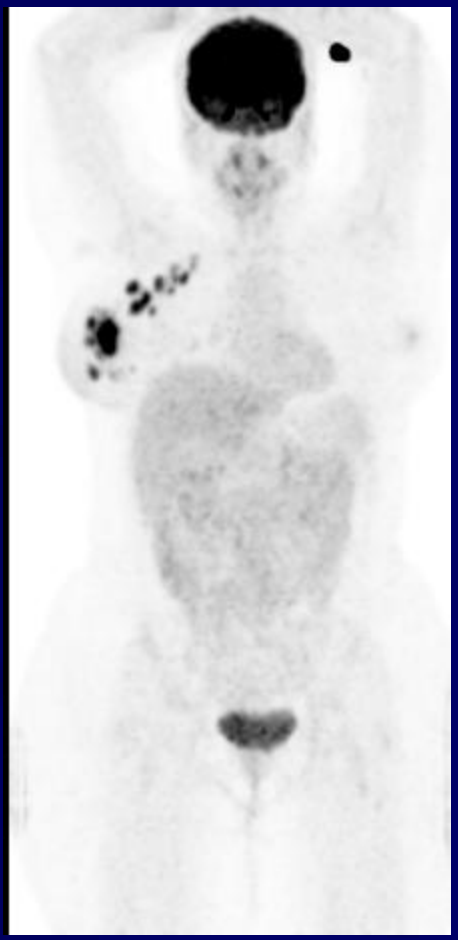
- **Monitoring response to therapy**
- **Suspected recurrence**

Rising markers

Characterization of suspected lesions

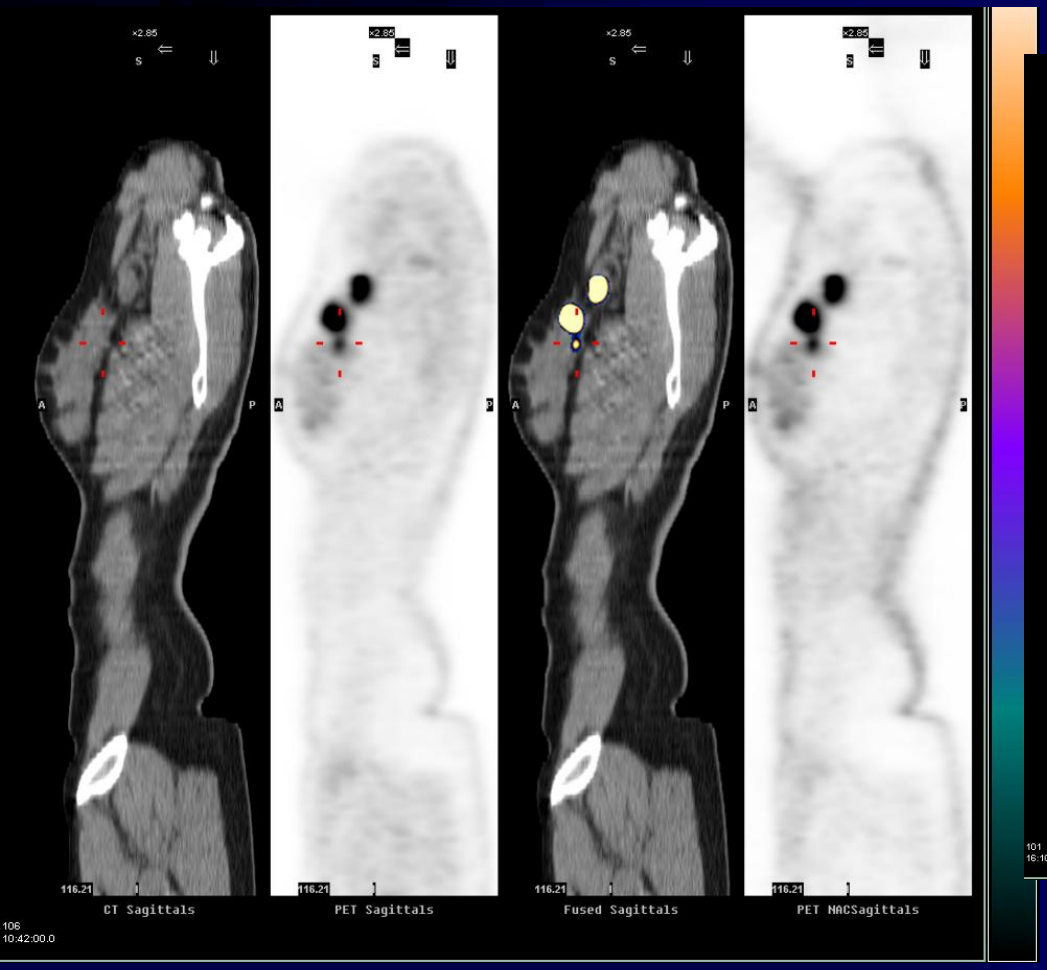
At Diagnosis

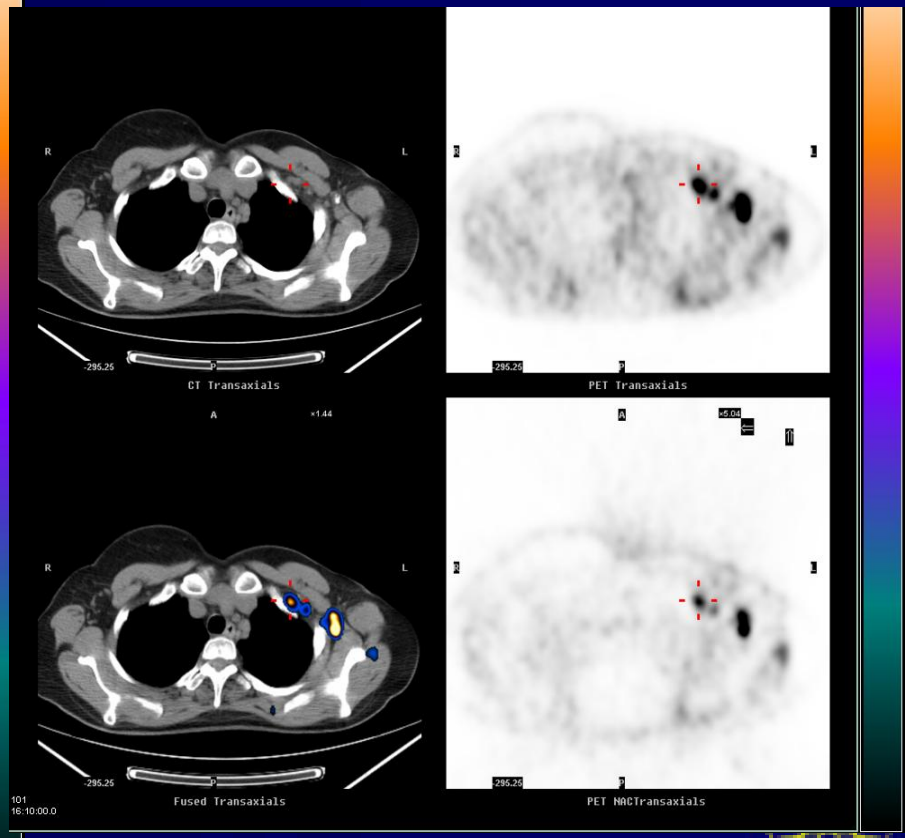
- Staging in patients with locally advanced or advanced stage disease



PET is not done as a routine in early stage disease

Detection of nodal involvement in normal-size lymph nodes

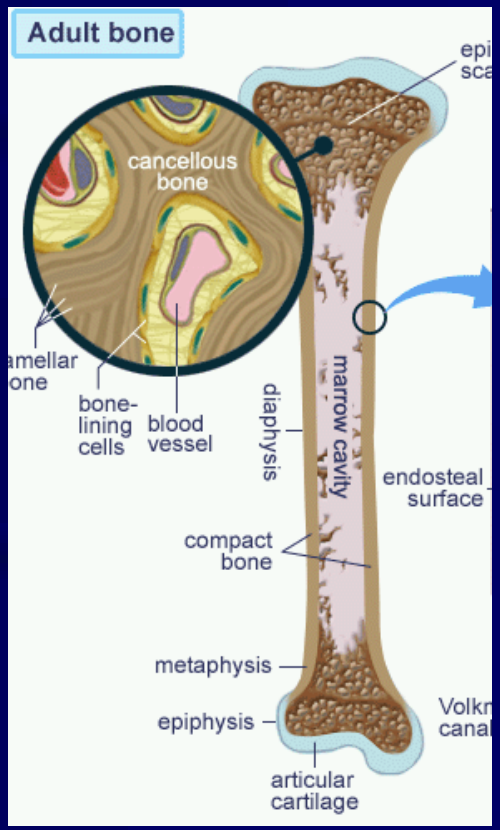




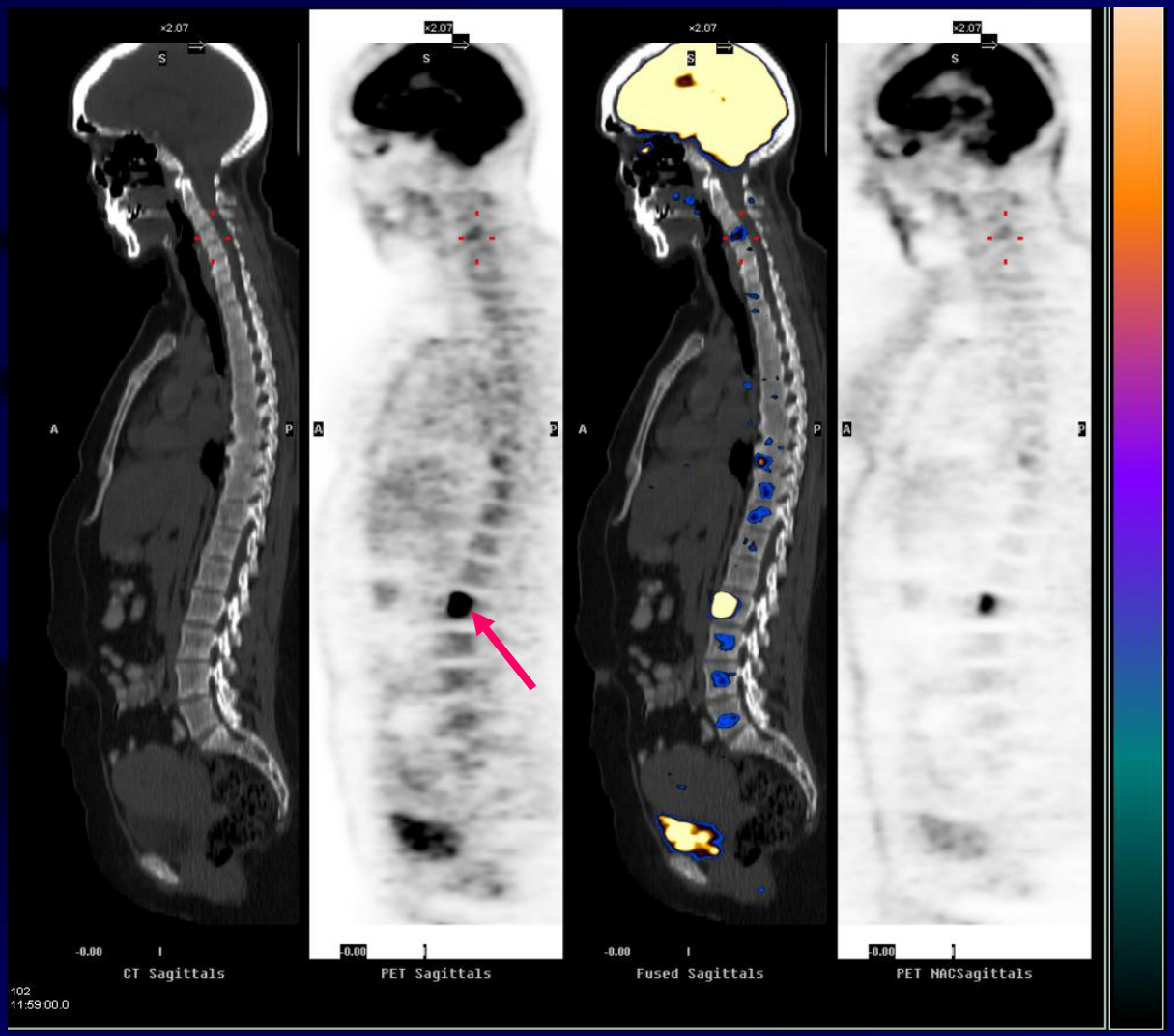
Remember: negative PET does not replace sentinel node assessment

Metastatic skeletal spread

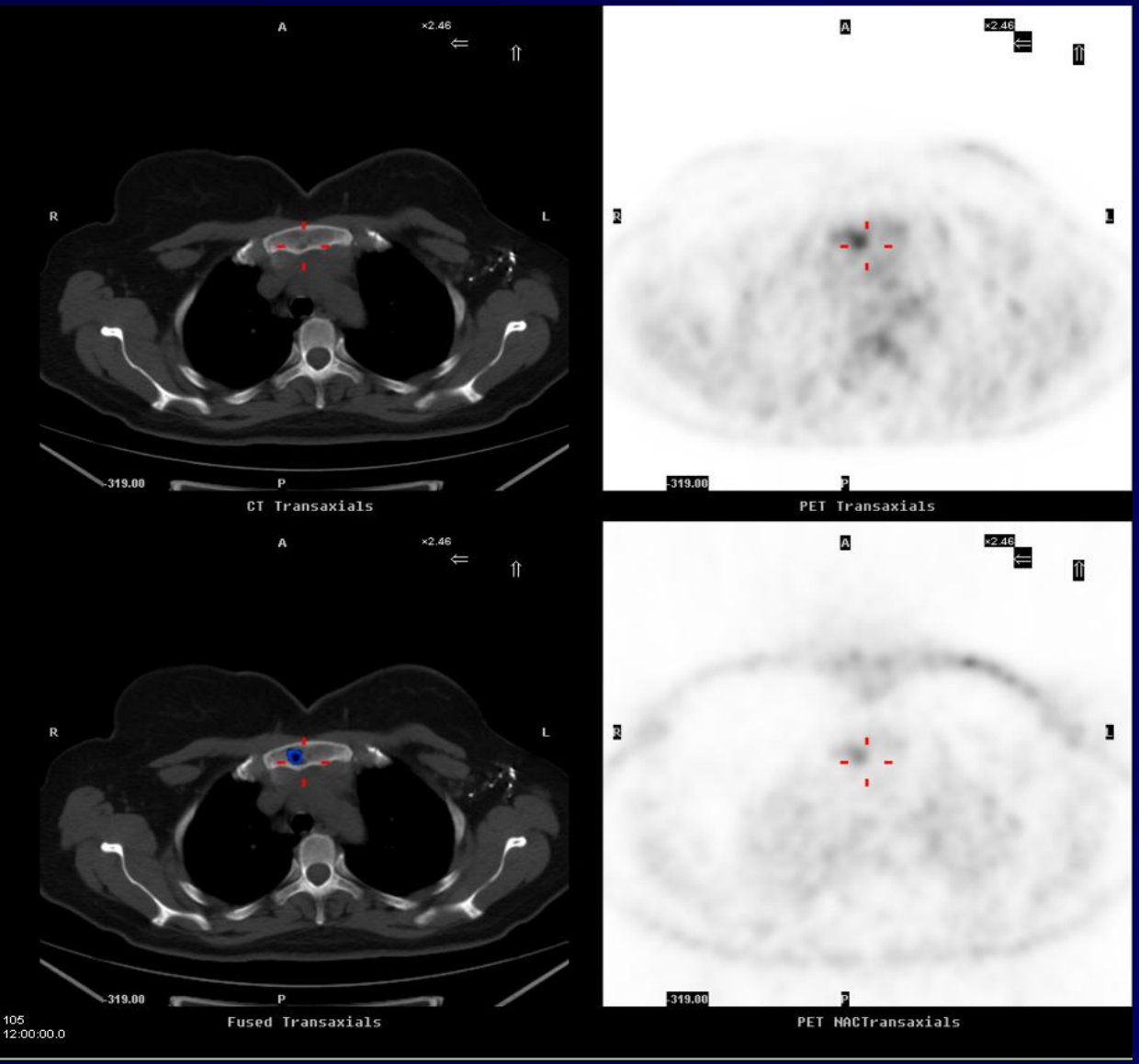
- Most bone metastases initiate as intramedullary lesions



Detection of early marrow-based lesions with normal bone morphology



Small lytic metastasis



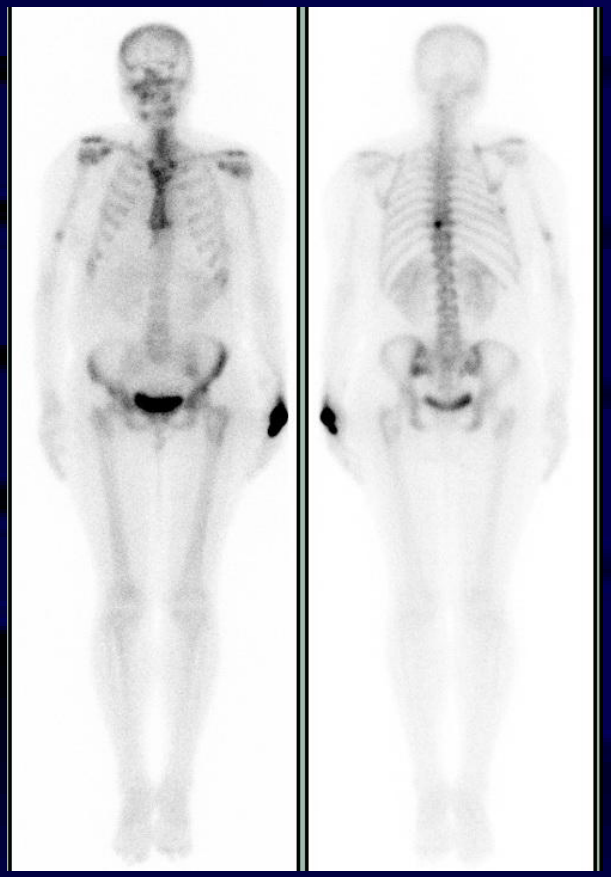
The greater avidity of ^{18}F-FDG in lytic metastases reflects glycolitic rate and the relative hypoxia characterizing this type of lesions

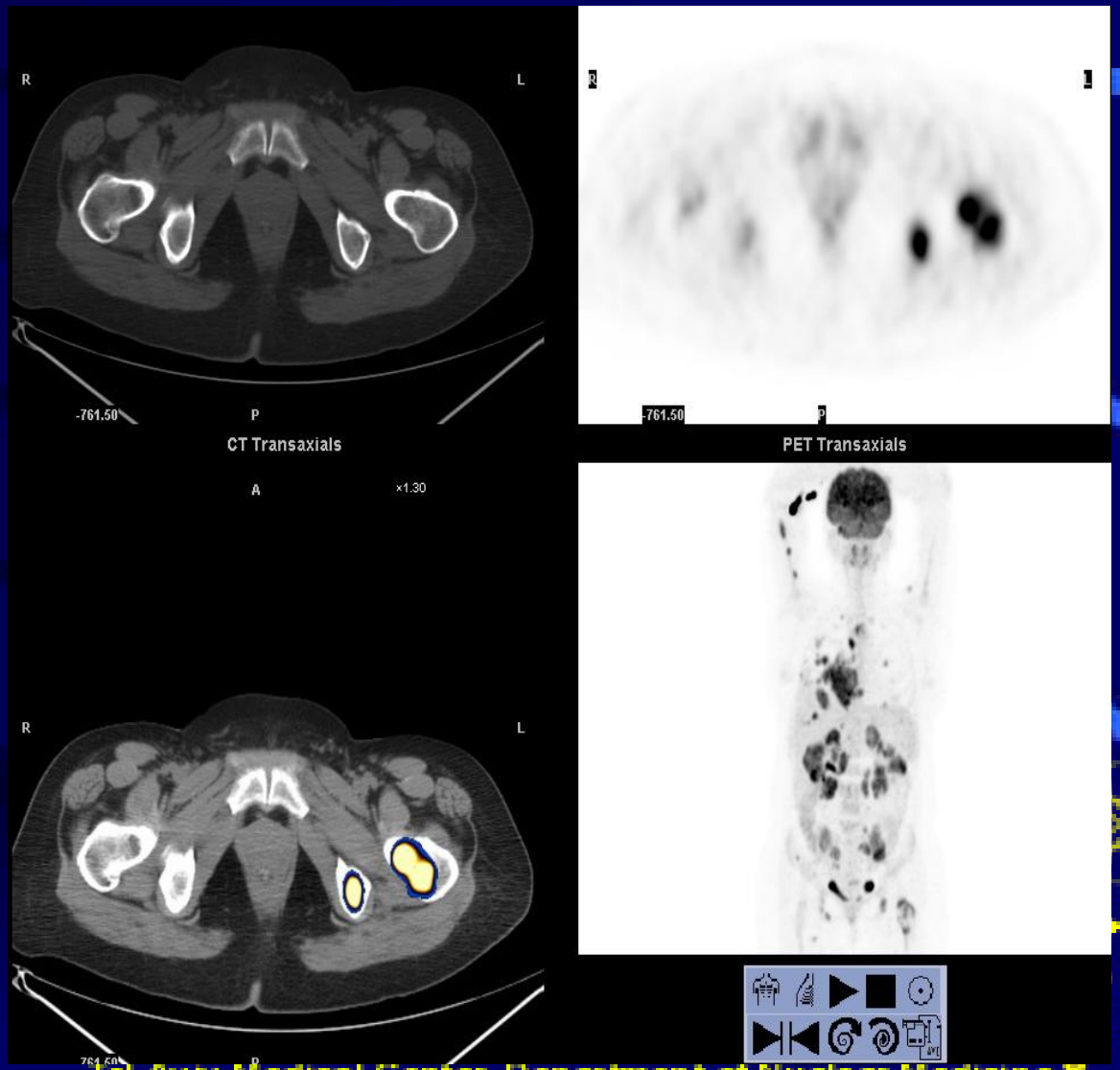
PET has been shown to be superior to bone scintigraphy in detecting bone metastases particularly lytic type and marrow-based metastases.

Performance of PET-CT in FDG-avid tumors obviates the need to perform bone scintigraphy

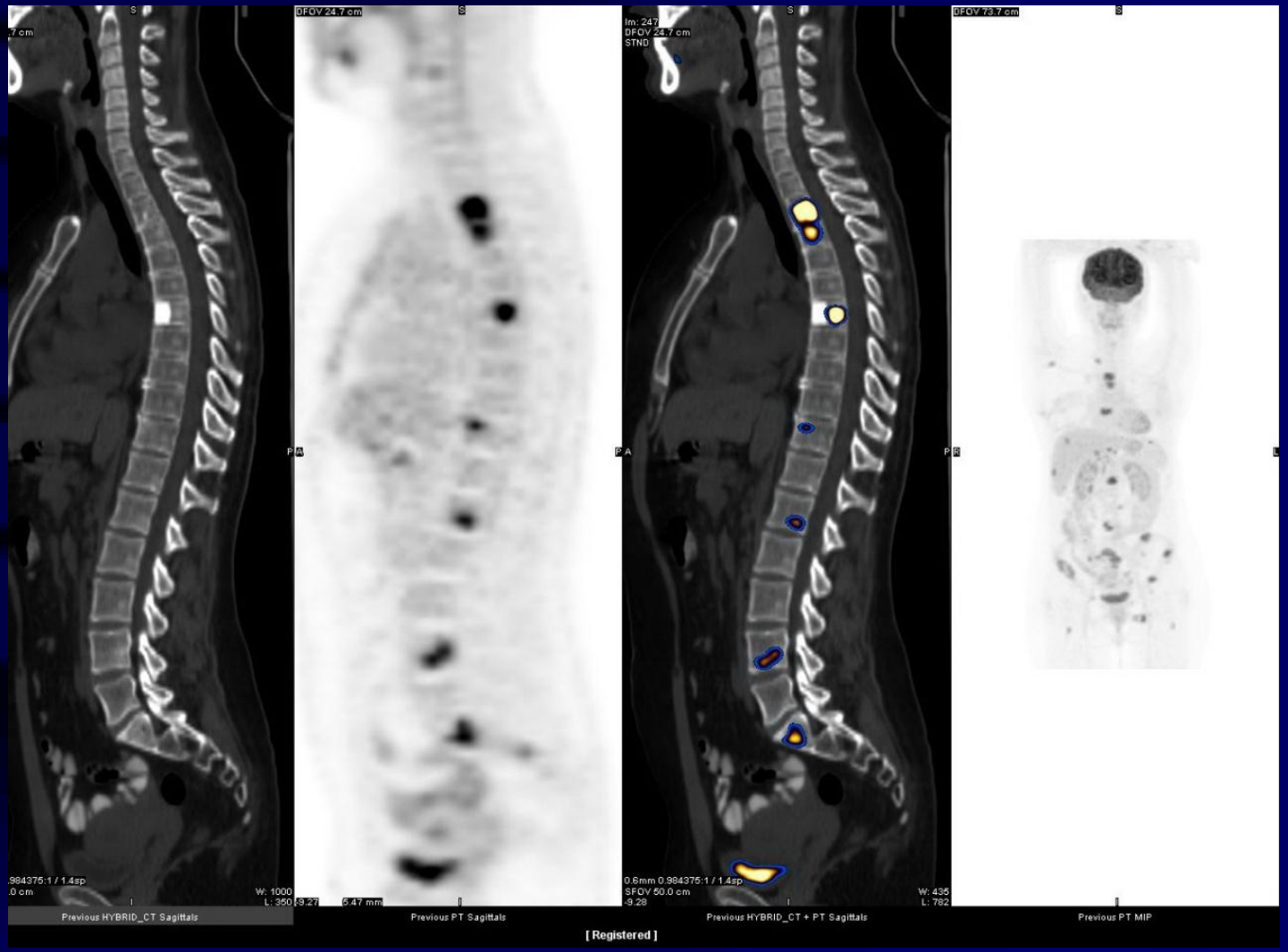
Bone scintigraphy

FDG PET-CT

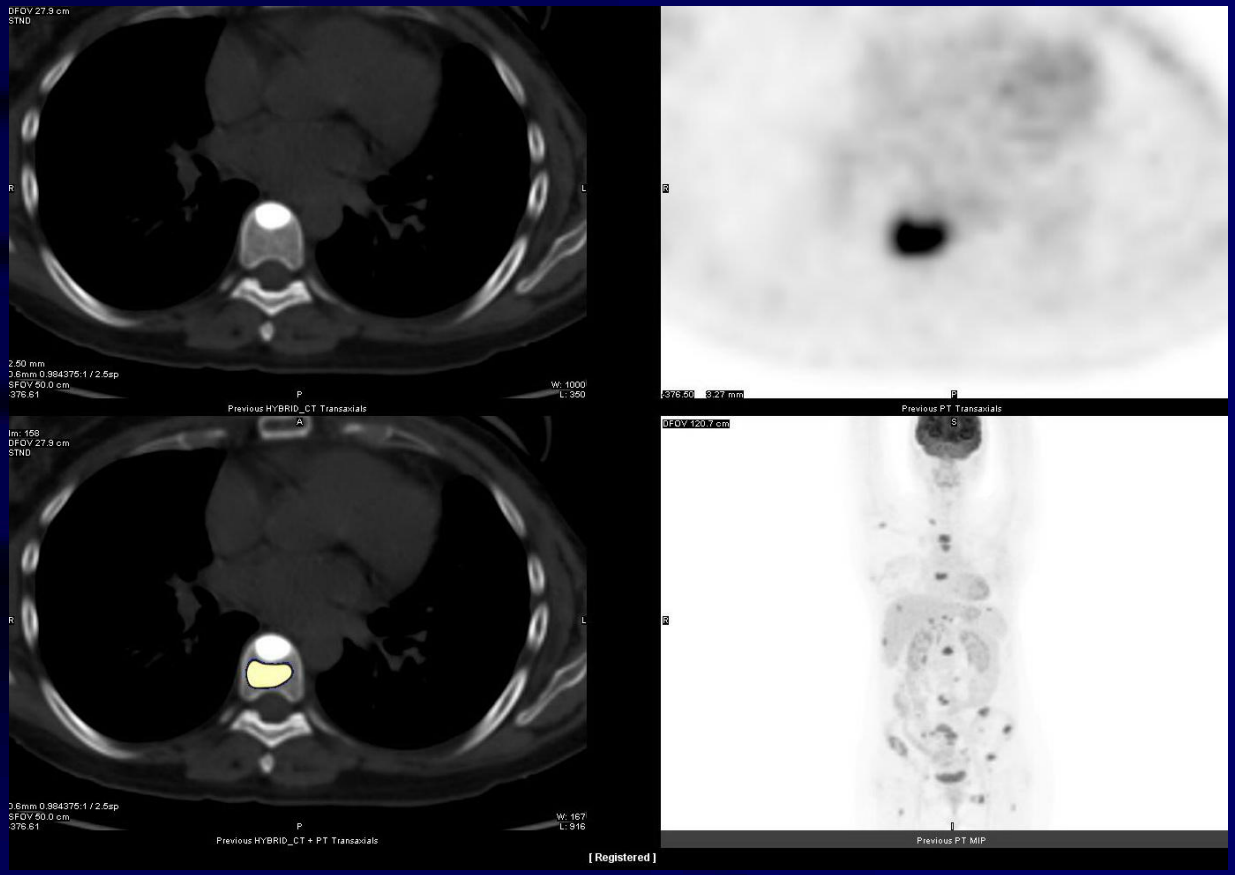




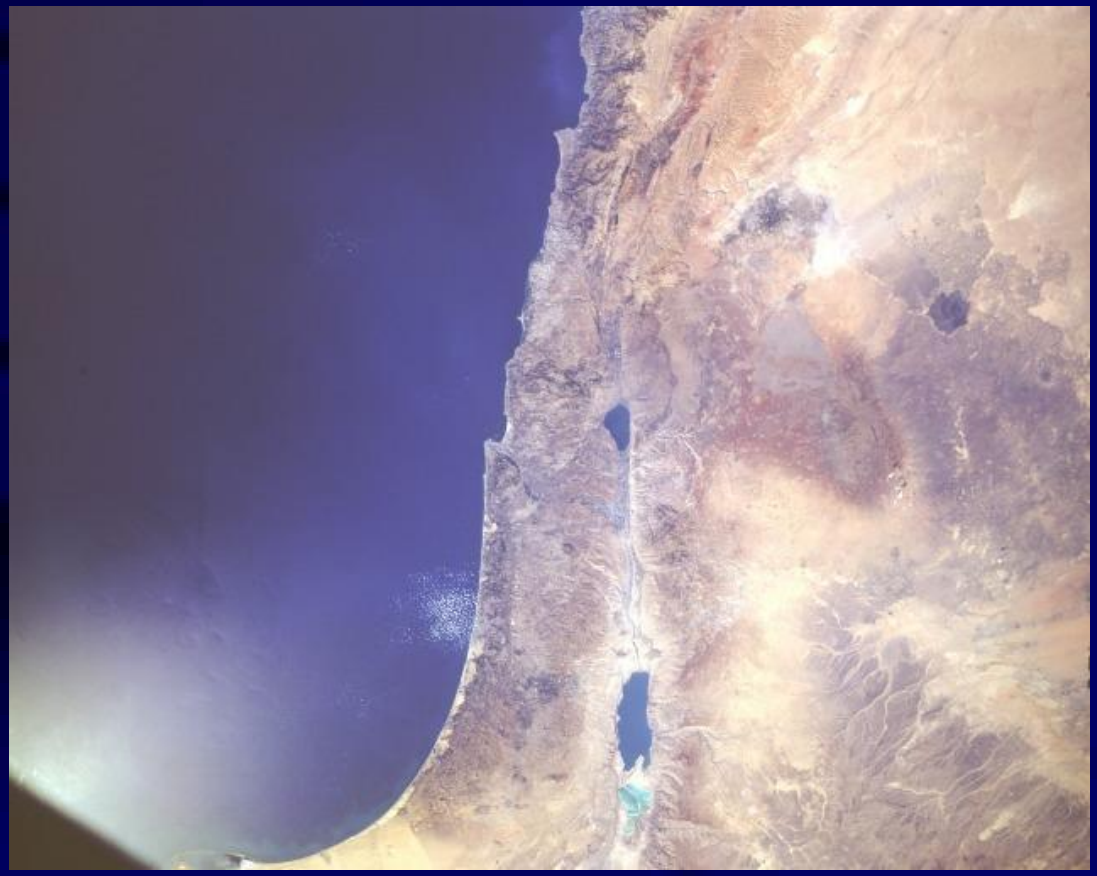
Assessing activity of bone metastases


DFOV 24.7 cm
DFOV 24.7 cm
STND
DFOV 73.7 cm
Previous HYBRID_CT Sagittals
Previous PT Sagittals
Previous HYBRID_CT + PT Sagittals
Previous PT MIP
[Registered]

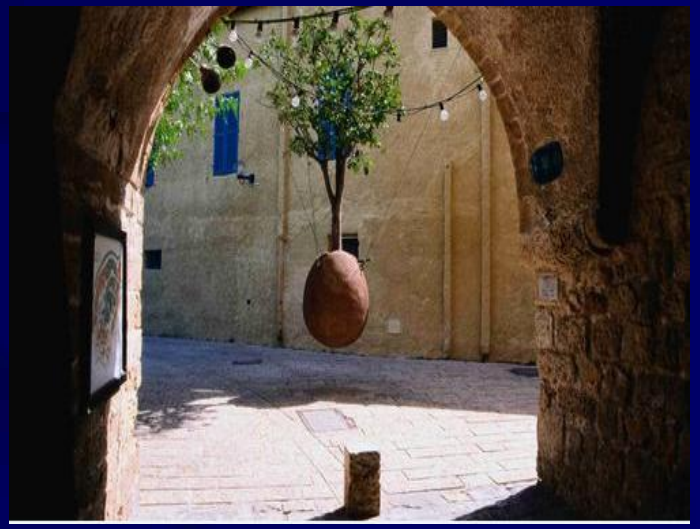
Sclerotic changes do not rule out active disease



Where is the PET-CT system in the department of nuclear medicine, Tel Aviv Medical Center, Tel Aviv, Israel



Where is the PET-CT system in the department of nuclear medicine, Tel Aviv Medical Center, Tel Aviv, Israel



Where is the PET-CT system in the department of nuclear medicine, Tel Aviv Medical Center, Tel Aviv, Israel

Tel-Aviv Medical Center, Department of Nuclear Medicine

Where is the PET-CT system in the department of nuclear medicine, Tel Aviv Medical Center, Tel Aviv, Israel

Where is the PET-CT system in the department of nuclear medicine, Tel Aviv Medical Center, Tel Aviv, Israel