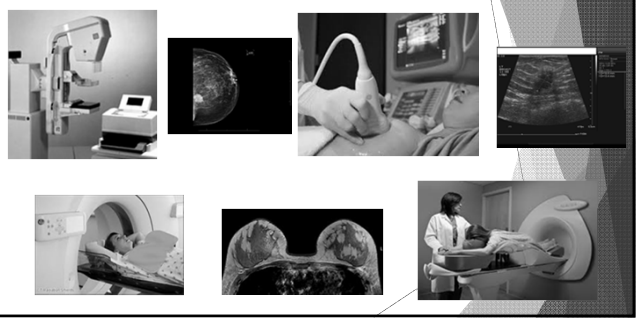
Staging patients through imaging modalities

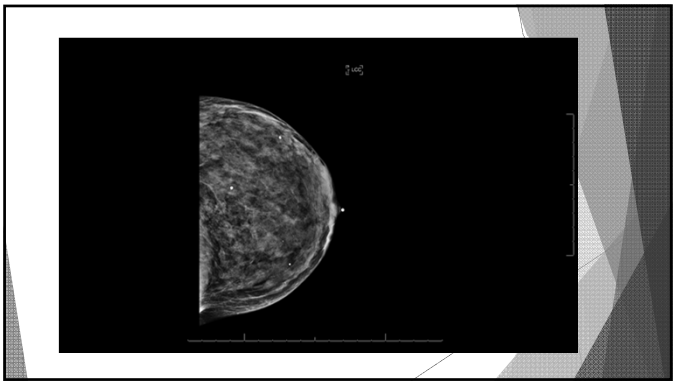


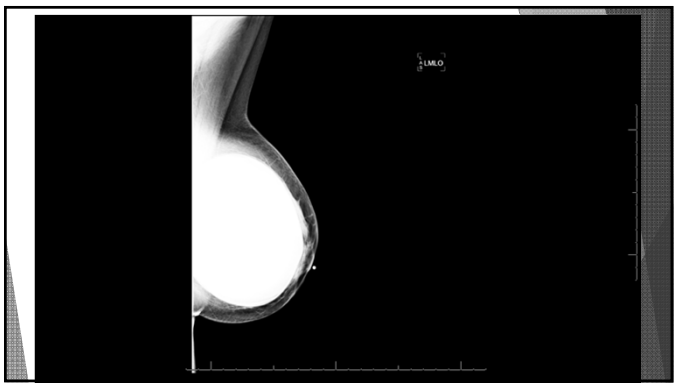
Breast Cancer Staging

- Mammography is still the number one breast modality to find breast cancer at the earliest stage possible.
- All other breast modalities are diagnostic tools to help find breast cancer along with screening mammography.
- So lets take a journey and look at these breast imaging tools.

Mammography

- Gold standard in United States to find breast cancer.
- Misses about 1-35 percent of breast cancers in breast
- Started table top, xeromammography, film/screen, digital, tomosynthesis.
- Different density categories can hinder finding breast cancer.

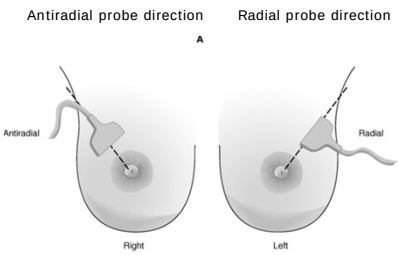




Breast Ultrasound

- Best demonstrates masses
- Hard to see calcifications
- Ultrasound helps distinguish between cysts (fluid-filled sacs) and solid masses. In someone with a breast mass, it can be used to look for enlarged lymph nodes. Breast ultrasound is often used to guide a needle to biopsy breast lesions and enlarged lymph nodes. It can also be used to guide a needle to draw fluid from cysts.
- Can Measure masses with three dimensions.
- Shows breast anatomy so lets learn some

Lesion Location Annotation

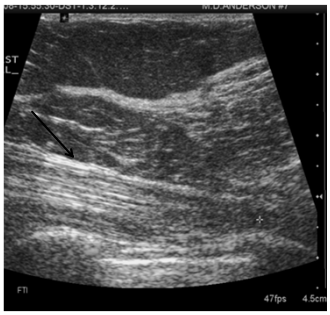


Radial 7 o'clock

Radial 9 o'clock

Antiradial 7 o'clock

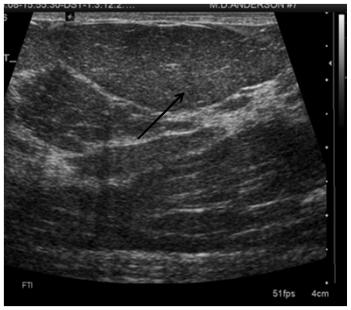
- Skin:
- Average skin thickness is from .5 – 2mm



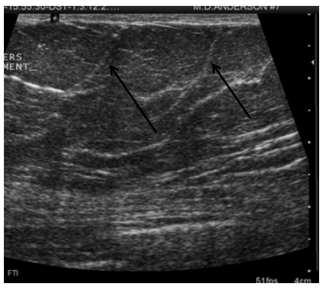
- Chest Wall:
- The pectoralis major and minor and the sternalis

- Nipple

- Lactiferus Duct:
- Carry milk from lobules to the lactiferous sinus.



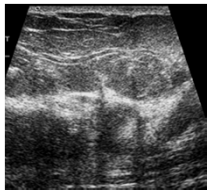
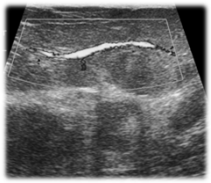
- Fat



- Cooper's Ligament:
- Dense supportive strands of fascia that connect to the skin.

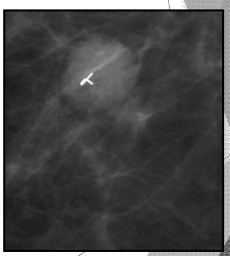
- Ribs

- Lymph Node:
- Part of the immune system. Helps to identify foreign

- Blood Vessels

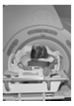
INRAD

BREAST MRI

- MRI of the breast is not a replacement for mammography or ultrasound imaging but rather a supplemental tool for detecting and staging breast cancer and other breast abnormalities.
- Medical studies are currently being conducted to determine whether MRI and other imaging methods can contribute to the early detection and prevention of deaths from breast cancer.

Breast MRI



- Assess multiple tumor locations, especially prior to breast conservation surgery.
- Identify early breast cancer not detected through other means, especially in women with dense breast tissue and those at high risk for the disease.
- Evaluate abnormalities detected by mammography or ultrasound.
- Distinguish between scar tissue and recurrent tumors.
- Determine whether cancer detected by mammography, ultrasound, or after surgical biopsy has spread further in the breast or into the chest wall.

Also to .....

Assess the effect of chemotherapy.

Provide additional information on a diseased breast to make treatment decisions.

Determine the integrity of breast implants.

In Most cases, an MRI exam is safe for patients with metal implants, except for a few types. People with the following implants cannot be scanned and should not enter the MRI scanning area unless explicitly instructed to do so by a radiologist or technologist who is aware of the presence of any of the following:

- Internal (implanted) defibrillator or pacemaker
- Cochlear (ear) implant
- Some types of clips used on brain aneurysms

- The MRI examination poses almost no risk to the average patient when appropriate safety guidelines are followed.
- If sedation is used there are risks of excessive sedation. The technologist or nurse monitors the vital signs to minimize this risk.

- There is a very slight risk of an allergic reaction if contrast material is injected. Such reactions usually are mild and easily controlled by medication. If patients experience allergic symptoms, a radiologist or other physician can be available for immediate assistance.
- Nephrogenic systemic fibrosis is currently a recognized, but rare, complication of MRI believed to be caused by the injection of high doses of MRI contrast material in patients with very poor kidney function.

What are the limitations of MRI of the Breast?

- High-quality images are assured only if pt's are able to remain perfectly still or hold their breath, if requested to do so, while the images are being recorded. If pt's are anxious, confused or in severe pain, pt's may find it difficult to lie still during imaging.
- A person who is very large may not fit into the opening of a conventional MRI machine.

- Although there is no reason to believe that magnetic resonance imaging harms the fetus, pregnant women usually are advised not to have an MRI exam unless medically necessary.
- MRI may not always distinguish between cancer tissue and edema fluid.

- MRI typically costs more and may take more time to perform than other imaging modalities.
- MRI of the breast cannot always distinguish between cancer and benign breast disease (such as fibroadenomas or fibrocystic change), leading to a false positive result. A false positive is a test result that indicates a suspicious finding when there is in fact no cancer present.

Why does the MRI Room Door have a release button to get in and out?

Questions you might have to answer for a patient.

How should I prepare for the procedure?
- Clothing – gowns or personal clothing with no metal **
- Eating or Drinking **
- Claustrophobia
- Leave Jewelry at home

What does the MRI look like and how does it work?

What will I experience during or after the procedure?

Who reads the MRI and how long will that take?

** Varies from facility to facility

How to prepare for MRI

Talk to physician about what an MRI is.

Call MRI department and speak to technologist.

Use the internet.

Take a family member or friend with you for comfort.

Contrast or No Contrast?

What are we looking for if we do NOT give contrast?

Breast Tissue Density

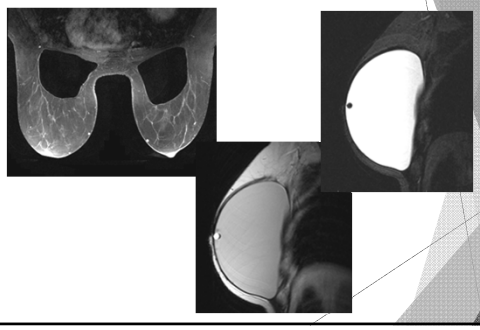
Cysts (usually benign)

Enlarged Ducts

Hematomas

Leaking or Ruptured Breast Implants

Leaking or Ruptured Breast Implants



Contrast or No Contrast?

What are we looking for if we give contrast?

Breast Abnormalities
(both benign or malignant)

If Malignant, size & shape of lesion

Presence of enlarged lymph nodes

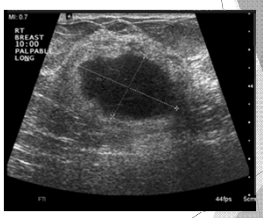
Basic Breast Imaging

Unilateral Breast Imaging

- Sagittal T2 w/ Fat Sat
- Axial T1 – at discretion of radiologist
- Bilateral Dynamic
  - Sagittal (to include axilla)
  - Axial
- Bilateral Axial T1 w/ Fat Sat – Post Contrast

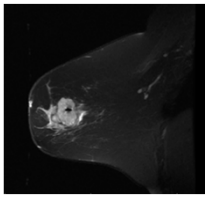
Unilateral Breast Study

Mammo done FIRST



Ultrasound done AFTER

Unilateral MRI Images



Sagittal T2 w/ Fat Sat

Dynamic Pre & Post Contrast

Unilateral MRI Images

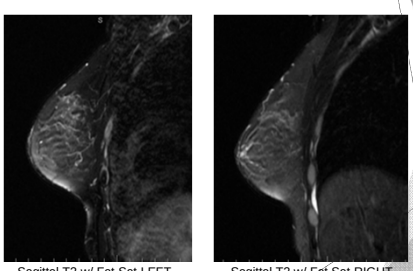
Axial T1 w/ Fat Sat Post Contrast

Basic Breast Imaging

Bilateral Breast Imaging

- Sagittal T2 w/ Fat Sat – Each breast separately
- Axial T1 – at discretion of radiologist
- Bilateral Dynamic
  - Sagittal (to include axilla)
  - Axial
- Bilateral Axial T1 w/ Fat Sat – Post Contrast

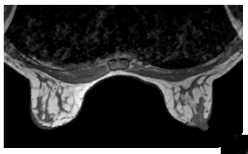
Bilateral MRI Images



Sagittal T2 w/ Fat Sat LEFT

Sagittal T2 w/ Fat Sat RIGHT

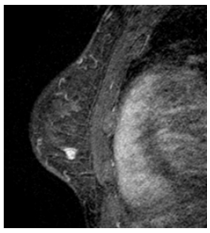
Bilateral MRI Images



Bilateral Axial T1

Bilateral Axial T1 w/ Fat Sat Post

Bilateral MRI Images



Bilateral Sagittal Dynamics

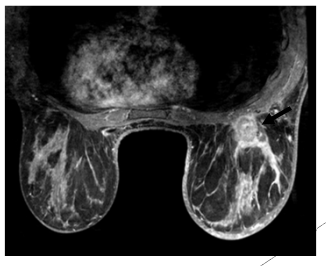
Why do we not scan <u>all</u> patients using the bilateral protocol?

- Scan Time
- Dynamic is Bilateral in Sagittal Plane
- T1 Post Contrast is Bilateral in Axial Plane

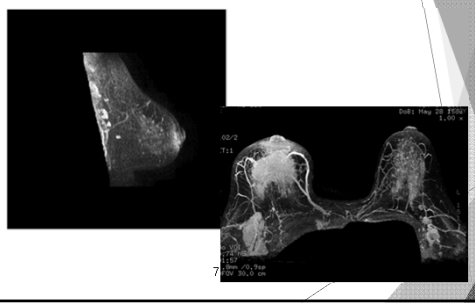
You get 2 planes bilaterally!

IDC

Grade 3



IBC



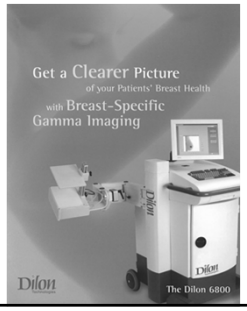
Metastatic Disease

Lymph Nodes
- axiallary
- superclavicular

Metastatic Disease

Liver

Breast Specific Gamma Imaging (BSGI)



The ComfortScan™ System
Imaging Breast-Specific Gamma

The differentiation of malignant and benign tissue.

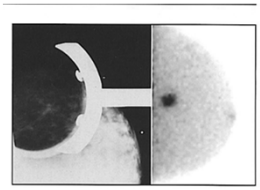
Nuclear medicine procedure that images the metabolic activity of breast lesions through radiotracer uptake.

Imaging is done using a high-resolution anatomic-specific gamma camera.

Used as a "next step measure" when post-mammogram evaluation is indicated.

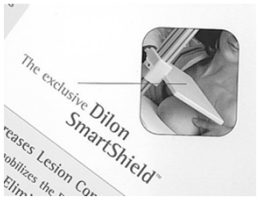
Scintimammography has long shown promise as a diagnostic tool for breast cancer detection however it was limited because it used a standard gamma camera and did not allow for the reliable detection of sub-centimeter lesions or direct correlation to mammograms

- Improves lesion contrast for detection of earlier stage cancers as small as 3 mm
- Located in breast centers for same-day diagnosis
- Mobile system-no installation costs



- Mammography remains the critical first screening measure
- BSGI images metabolic activity which aids in the differentiation of benign and malignant masses
- Metabolic imaging of nuclear medicine is less effected by variations in tissue density
- Offers a vital adjunct to mammography and ultrasound

Crainocaudal view



POSITRON EMISSION MAMMOGRAPHY (PEM)

Breast Cancer Diagnostics – A Historical Perspective

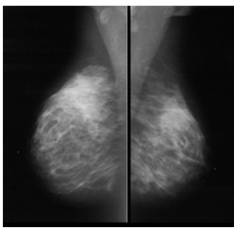
- In 1980, average size of breast cancer lesion = 2.6 cm …the treatment was radical mastectomy
- In the 1990s, treatment progressed to modified mastectomy for smaller tumors
- Today, median size of breast cancer ~1.5 cm, lumpectomy with irradiation is the approach of choice, IF there is an absence of additional disease
- However, one in three women have index lesions less than 1 cm in size making it even more difficult to localize satellite lesions and DCIS using current imaging modalities

Simple conclusion?

Need improved detection for cancers < 1.0 cm

60

Imaging via a Traditional Mammogram



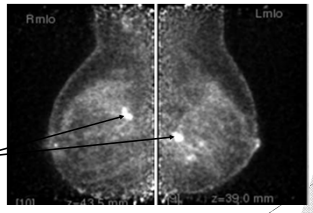
40 y/o female who was told following her first mammogram that she had an area of density in the left inferior part of the breast

She had additional imaging (US bx & MRI) which confirmed invasive ductal carcinoma…

61

Imaging at the Molecular Level

…PEM found bilateral cancer.



Cancer

PEM Images

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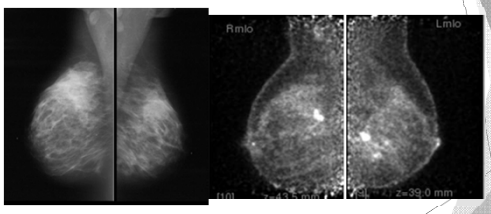


PEM Flex™ Solo II

- High (1.5 – 2.0 mm) spatial resolution
- Short 4-10 minute scan time
- Compact, portable, easy to use
- High Value 3-D tomographic PET images
- Gentle Immobilization vs. Compression

64

Diagnostic Value – The Power of PEM

- Sensitivity and specificity are <u>key</u> to early detection of breast cancer lesions
- PEM Flex demonstrated >90% "sensitivity and specificity" (TBJ; Vol. 12 #4)
- MRI false positive rate is an issue in diagnosis and accurate image reads

Parameter	Mammo	SPECT Gamma	WB PET	Breast MRI	PEM Flex
Sensitivity	66-88%	89%(>1cm)	50 - 80%	91%	91%
Specificity	<50%	68%	76%	60-90%	93% - 98%

65

How does PEM differ from PET?

Both

Provide "functional" imaging and use FDG (fludeoxyglucose or fluorodeoxyglucose)

PEM

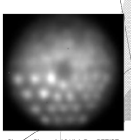
- Optimized for small body parts
- Gentle immobilization
- Designed for patient comfort
- $850K

PET

- Whole Body Imaging
- $2-3 Million

1-2 mm spatial resolution

5-6mm resolution



Siemens Biograph 16 High Res PET/CT

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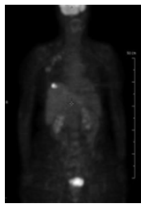
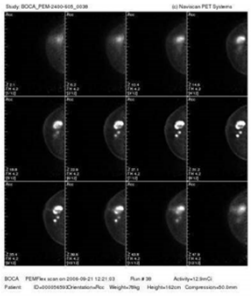
PET and PEM





Images Courtesy Dr. Kathy Schilling, MD
Boca Raton Community Hospital

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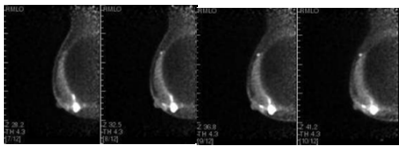
PEM and Implants



History: 45 y/o female with breast implants. PEM done as an adjunct to conventional imaging.

Findings: PEM showed hypermetabolic retroareolar lesion and 2nd focus of uptake right upper outer quadrant.

Pathology: Retroareolar lesion –IDC, DCIS
Upper out quadrant lesion- IDC

Images Courtesy Diagnostic Specialty Imaging, Bensalem, Pennsylvania

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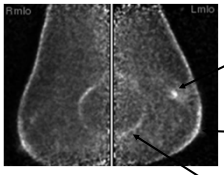
PEM and Implants

Can see through the implant to the posterior side



Cancer

Nipple

Implant

Images Courtesy Dr. Kathy Schilling, MD
Boca Raton Community Hospital

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Advantages

- Shows glucose uptake in cancer cells
- FDG – no significant allergic reactions
- Not affected by hormonal modulated dense breast
- Less expensive device
- No claustrophobia
- Good diagnostic capability for DCIS

Disadvantages

- Uses radiation

70

21

The LumaGem molecular breast imaging (MBI) camera is a dedicated breast imaging system with cadmium zinc telluride (CZT) digital detectors.

MBI

- MBI is the latest arrival in a new generation of functional breast imaging technology designed to overcome the limitations of anatomic breast imaging.
- Though mortality rates have declined, breast cancer remains a nefarious disease. In the U.S. alone, it killed more than four women every hour of every day in 2006, the last year for which complete data are available.

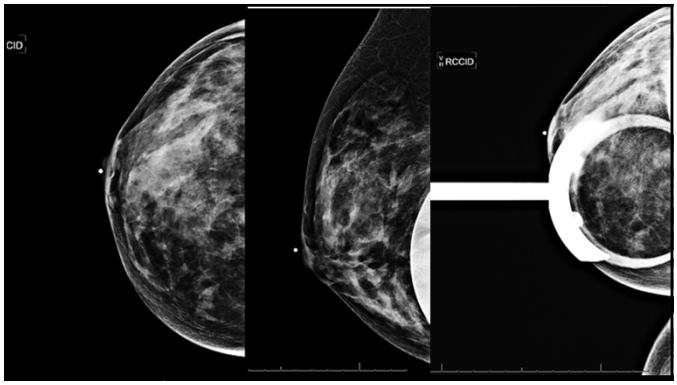
- MBI shares family ties with other functional approaches to breast imaging, including breast-specific gamma imaging (BSGI) and positron emission mammography (PEM). All three capitalize on diagnostic nuclear imaging methods

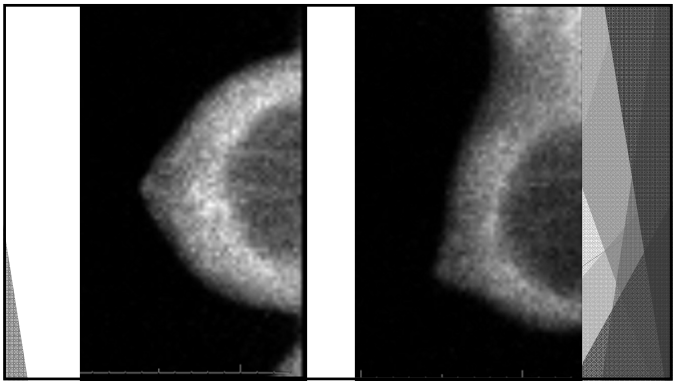
- MBI and BSGI employ gamma cameras specifically designed for breast examination using technetium-99m (Tc-99m) sestamibi, the preferred radiopharmaceutical probe for tumor localization and imaging. Tc-99m is the workhorse radioisotope for such single-photon imaging. Sestamibi concentrates in cells with increased mitochondrial density, a common condition for metastatic breast disease

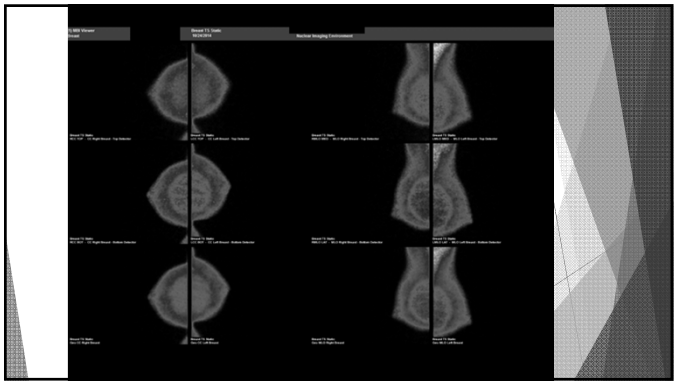
- MBI proponents believe that it could first have a role in breast cancer screening for at-risk populations, and possibly later aid older women in the general population. The realization of that vision could lead MBI into the mainstream of breast imaging, a goal that neither BSGI nor PEM have yet realized. But MBI developers acknowledge they will have to reduce the radiation dose from MBI before it will be acceptable for screening use.

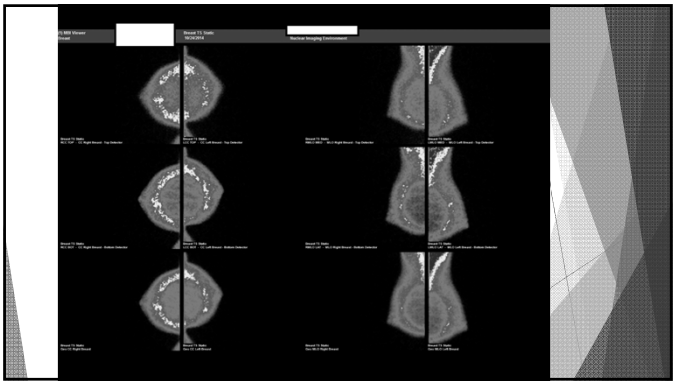
Case Study # 1

- Area was seen on right breast in the CC view only
- Spot view was inconclusive and U.S. was negative
- MBI was ordered



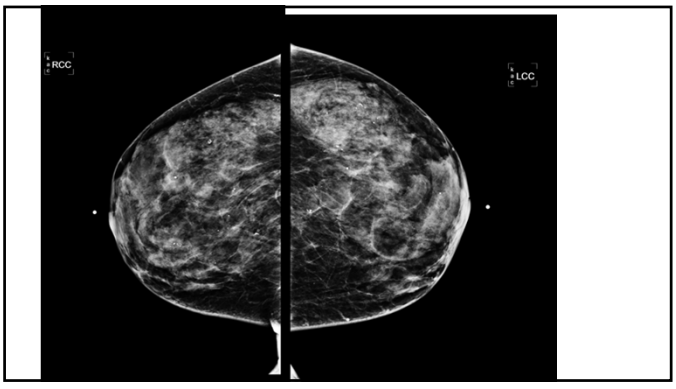


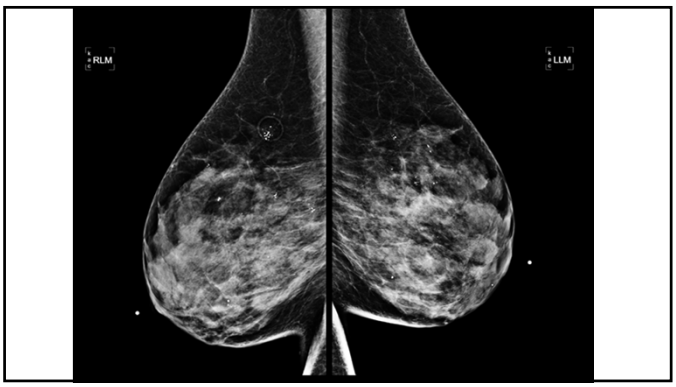


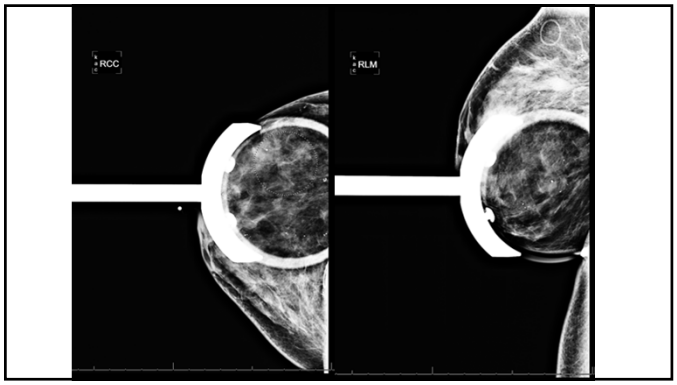


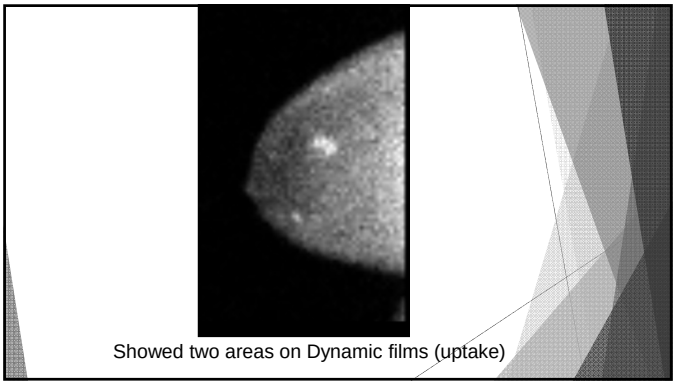
Case Study #2

- 64 year old female
- Outside facility diagnosed a right IDC at 9:00
- Had US which confirmed the cancer – otherwise no new findings
- Decided on MBI exam which showed two areas of uptake in the right breast 9:00 and 4:00
- Had a repeat US which did show another cancer at 4:00 -- Invasive Mucinous

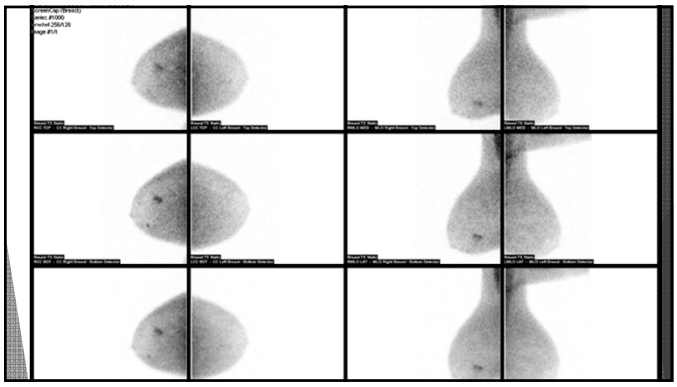


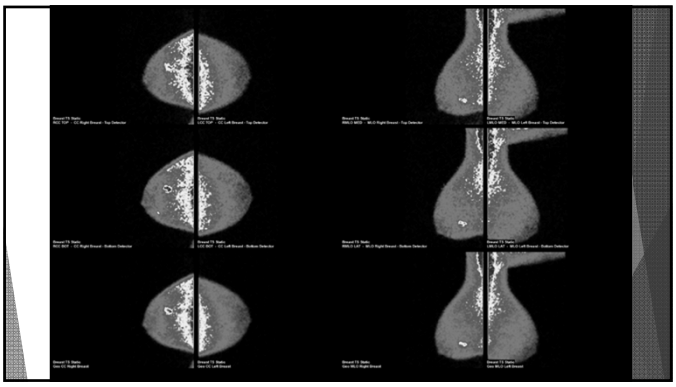


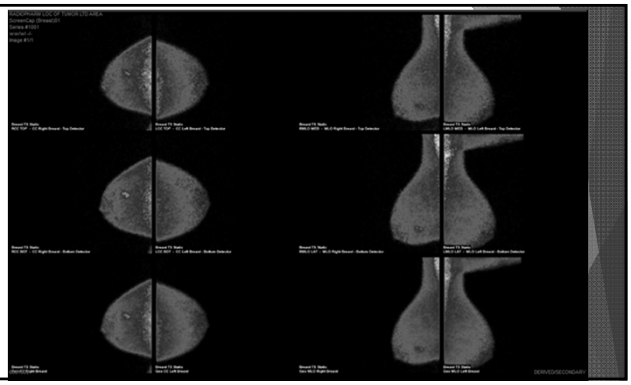




Showed two areas on Dynamic films (uptake)







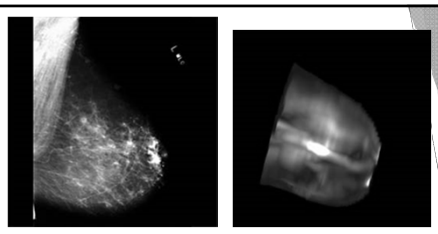
CTLM-Computed Tomography Laser Mammography

Computed Tomography Laser Mammography CTLM

Unlike x-ray mammography, CTLM images blood hemoglobin and the process of neoangiogenesis or new vessel formation which is often associated with breast cancer.

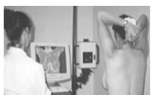
- CT Laser breast imaging is part of the field of optical imaging
- CTLM images blood flow to the breast to identify tumors
- CTLM doesn't use ionizing radiation
- CTLM images through implants and dense tissue easily
- There is NO breast compression – the breasts hang in the machine in it's natural position
- The average scan time is about 10-15 minutes per breast

- The current CTLM will initially be used in conjunction with x-ray and ultrasound to assist in differentiating malignant from benign lesions and help reduce the great number of invasive biopsies performed which later prove to be negative.

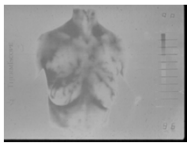


Extensive microcalcification unchanged from prior mammograms but patient now feels lump.
This standard CTLM maximum intensity (MIP) projection, shows a large central vessel (normal) but a mass of irregularly shaped neovascularity behind this.

- 1970's-
- Thermography



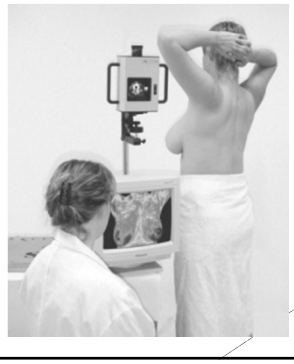
Right Medial 3.4 ca



Right Fibroadenoma

Left ca

Now there is Breast Thermography DITI



Why would I want to use Thermography for breast screening?

Active Cancer Cells Can Double in Number Every 90 Days

90 days	2 cells	
1 year	16 cells	
2 years	256 cells	
3 years	4,896 cells	
4 years	65,536 cells	(still undetectable with mammogram)
5 years	1,048,576 cells	
6 years	16,777,216 cells	
7 years	268,435,456 cells	(doubled 32 times)*
8 years	4,294,967,296 cells	

*Usually detectable by Mammogram at this stage
40 Doublings (Approx 10 Years) considered lethal
Thermal Imaging can detect growth patterns in the 2nd year!
Why wait until it's too late? Schedule Thermal Imaging NOW!

Based on the theory….

- Angiogenesis, or new blood vessel formation, is necessary to sustain the growth of a tumor. Breast thermography may be the first signal that such a possibility is developing.

- Breast thermography offers women information that no other procedure can provide. However, breast thermography is not a replacement for or alternative to mammography or any other form of breast imaging. Breast thermography is meant to be used in addition to mammography and other tests or procedures.

- Breast thermography and mammography are complementary procedures, one test does not replace the other. All thermography reports are meant to identify thermal emissions that suggest potential risk markers only and do not in any way suggest diagnosis and/or treatment.

- The use of Digital Infrared Imaging is based on the principle that metabolic activity and vascular circulation in both pre-cancerous tissue and the area surrounding a developing breast cancer is almost always higher than in normal breast tissue.

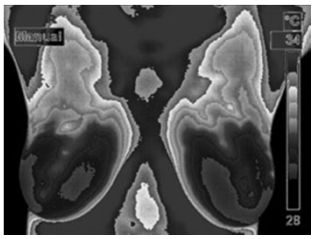
- In an ever-increasing need for nutrients, cancerous tumors increase circulation to their cells by holding open existing blood vessels, opening dormant vessels, and creating new ones (**neoangiogenesis**).
- This process frequently results in an increase in regional surface temperatures of the breast.
- Breast Thermography uses ultra-sensitive medical infrared cameras and sophisticated computers to detect, analyze, and produce high-resolution diagnostic images of these temperature variations.

The Procedure

- The patient is left for 15 minutes in order for your body to reach a steady temperature state in equilibrium with the special temperature conditions of the room (19C-23C). About 66-73 F
- The patient is positioned in front of the imaging system so that all of the surfaces of the breasts, upper chest, and under arms are imaged.

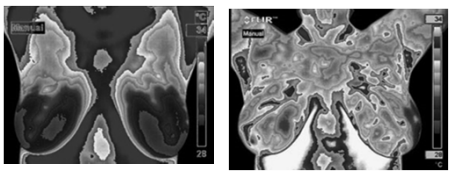
- **The images are captured in real-time from an ultra-sensitive medical infrared imaging camera** and sent to a sophisticated computer for storage and analysis (the images are kept on archival media for precision comparison of future images so that the breasts can be monitored over time). Sophisticated computer programs allow the doctor to isolate temperature differentials, perform vascular analyses, dynamic thermal subtraction studies, and more.

- **After the images have been analyzed, they are graded** using a strict standardized reading protocol. Each breast's image is placed into one of five thermobiological (TH) categories:
- **TH 1** – Normal uniform non-vascular
- **TH 2** – Normal uniform vascular
- **TH 3** – Equivocal (questionable)
- **TH 4** – Abnormal
- **TH 5** – Severely abnormal

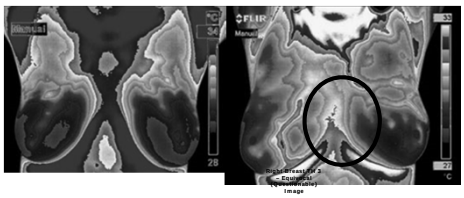


COLD HOT

- TH 1 Uniform Non-Vascular

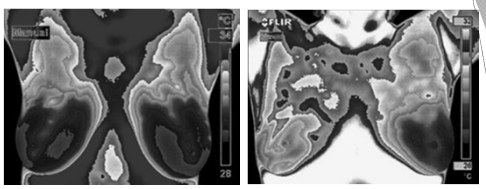


- TH 2 ESTROGEN DOMINANCE
- Note the symmetrical streaks of orange and red in both breasts (blood vessels). This increase in metabolism is caused by a relative progesterone deficiency (estrogen dominance). Finding this and correcting the problem may play a significant role in breast cancer prevention.

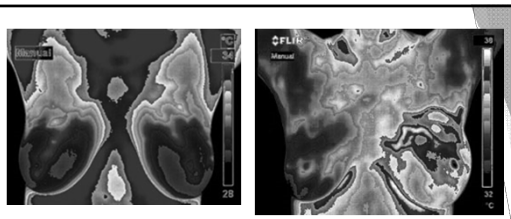


Right Breast TH 3 – Equivocal (Questionable) Image

Note the single hot blood vessel in the right breast. This finding will need to be watched over time for change. If it remains stable, or improves, the finding is normal for the physiology of this patient.



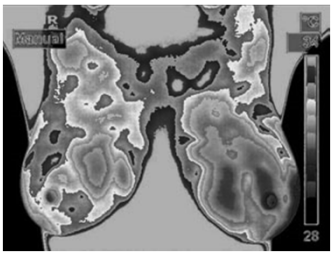
- **Right Breast TH 4 – Abnormal Image**
- Note the increased temperature (metabolism) of the right breast. There are three suspicious areas of higher temperatures. Especially significant is the highly vascular area closest to the right nipple.



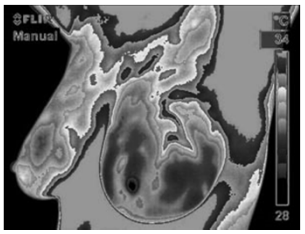
- **Left Breast TH 5 – Severely Abnormal Image**
- **Note the intensely increased temperature (metabolism) and vascularity of the entire left breast. In this case, a recent mammogram was negative. This is a patient with inflammatory carcinoma in the left breast. This image served to direct the patient for immediate care.**

Case 1

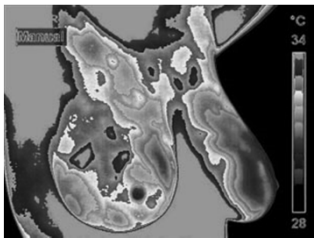
- Lump right breast
- Had negative mammogram



- Significant heat and Vascularity in right breast especially over the area of the palpable lump in the upper outer quadrant



- Left breast shows to be cool with normal limited vascular pattern



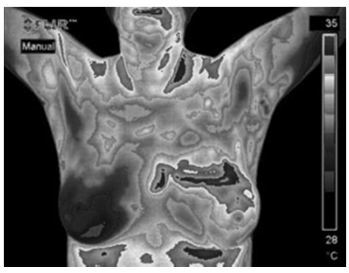
- Right breast with area of lump directly facing the infrared detector. Increased heat and Vascularity are very evident.

Diagnosis

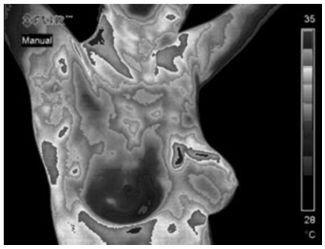
- Invasive ductal

Case 2

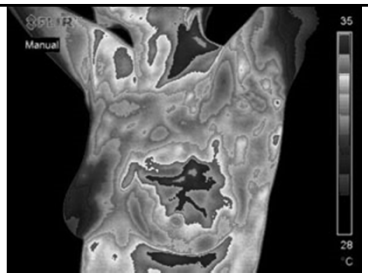
- Recent mammogram was normal
- Ultrasound was also done and recommended repeat imaging in 6 months
- Patient's doctor was concerned over a thickening of the left breast during CBE.



- Significant increase in temperature of the entire left breast with noticeable vascularity.



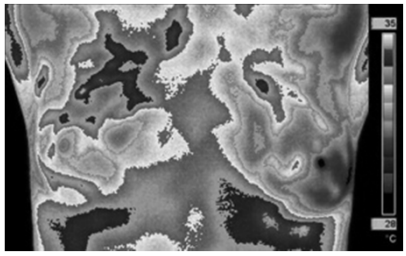
- Right breast normal and cool without evidence of suspicious blood vessel activity.



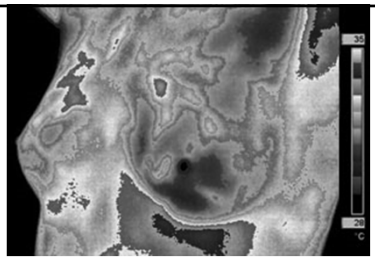
- Left breast has significant amount of thermovascular activity
- Patient referred back to her doctor for biopsy
- Inflammatory CA

Case 3

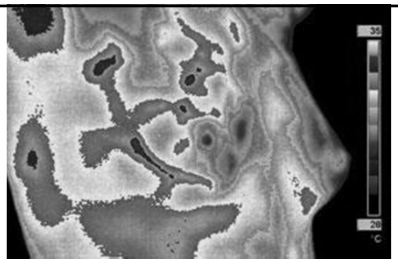
- 19 year old with lump in right breast
- Had CBE and doctor felt it was a cyst
- Patient insisted on further testing
- Mammogram and ultrasound were done and both were negative.



- Aggressive increase in temperature and vascularity in right breast



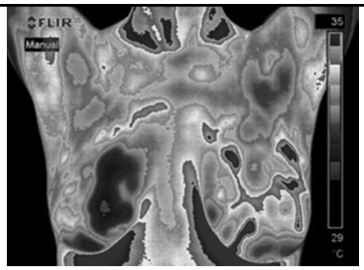
- Left breast is cool and without suspicious vascular pattern



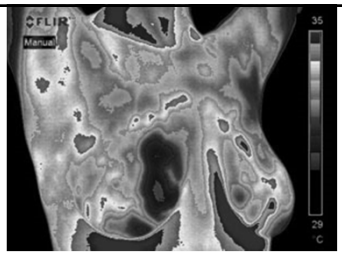
- Right breast shows a single large hot blood vessel leading to the area of the lump
- Referred back to doctor for biopsy
- Invasive ductal with DCIS

Case 4

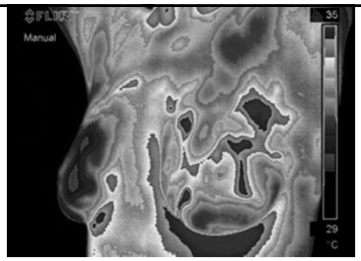
- 42 YO with pain in left breast
- Negative CBE



- Significant increase in temperature and vascularity in left breast



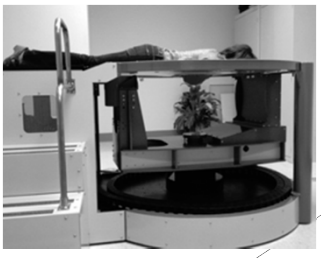
- Right breast shows some heating but no suspicious patterns



- Left breast large hot and engorged blood vessels throughout most of the breast
- Referred back to her doctor for mammogram and ultrasound
- Mammogram and ultrasound showed a suspicious area in left breast
- Invasive ductal

Fee: $150 *for baseline, 3 months later* ***$130*** *for comparison*
Thereafter, yearly appointments are ***$160***

Dedicated Breast CT Scanner



Breast CT Scanners

- John Boone, PhD. has developed a dedicated breast CT scanner at the University of California in 2001.
- It produces 3-D images of the breast to help radiologists detect those hard-to-find tumors.
- A breast CT scanner has better contrast resolution than mammography.
- The scanner has an x-ray tube and detector -positioned on opposite sides of a patient.
- It rotates 360 degrees while sending x-rays through the body at many different angles.

National Institute of Biomedical Imaging and Bioengineering (NIBIB)

Dedicated Breast CT Scanner

- Created by John Boone, PhD and his research team at the University of California in 2001
- His colleagues originally thought CT would do more harm than good
- Boone believed that the dose would be greatly reduced if only the breasts were imaged
- Since 2004 used on 600 women in clinical trials
- Clinical trials now being done in Georgia and New York
- 300 images in 16 seconds
- Higher contrast 3-D images
- No compression

Dedicated Breast CT Scanner

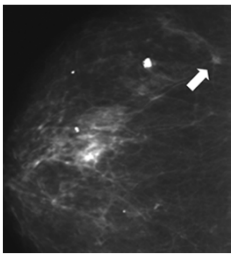
- Breast can be imaged in three dimensions and could help to detect hard-to-find tumors
- The scanner uses a radiation dose comparable to standard x-ray mammography and doesn't require compression of the breast. An image takes 16.6 seconds
- Optimized the scanners by integrating imaging modalities such as positron emission tomography (PET) and contrast-enhanced CT.
- After 45 minutes for uptake of a radioactive sugar molecule, patient is scanned to see whether a tumor is present

Boone's Breast CT Scanners

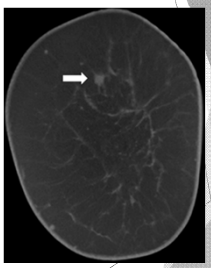
- Each rotation produces a series of cross-sectional images or "slices" and multiple slices are acquired along the length of the subject while moving through the scanner.
- The slices are then reconstructed by a computer to generate a composite 3D image that radiologists can view as an entire volume or as component slices.
- Radiation dose is comparable to standard x-ray mammography and doesn't require compression of the breast.

National Institute of Biomedical Imaging and Bioengineering (NIBIB)

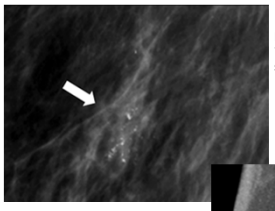
Dedicated Breast CT Scanner



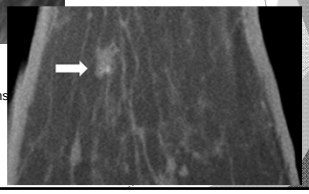
CC view shows 4 mm IDC



Coronal view CT shows 12:00 4mm IDC

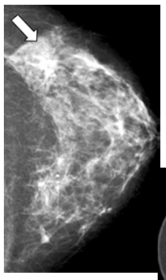


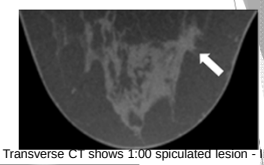
Right CC spot magnification view shows 7 mm cluster of califications – arrow shows DCIS mass



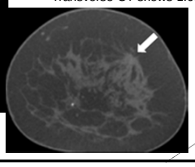
Transverse CT shows calcifications in an ill-defined lesion (DCIS)

LCC view shows 1:00 spiculated mass





Transverse CT shows 1:00 spiculated lesion - IDC



Coronal CT shows
1:00 spiculated mass
IDC

Pros and Cons for Breast CT

- Many women found it difficult to arch forward into the scanner, their necks were uncomfortable and the table too firm. (6.7)
- Holding breath for 16.6 seconds (7.7)
- Overall comfort (7.9)
- Breast CT versus getting a mammogram (10)

Sc

Question	Score	
	Mean ± SD	Median*
Position†	6.7 ± 2.6	7 (6.1, 7.9)
Breath hold‡	7.7 ± 2.3	8 (7.3, 8.7)
Comfort§	7.9 ± 2.1	8 (7.1, 8.9)
Breast CT vs mammography‖	8.9 ± 1.9	10 (10, 10)