

# Women's Imaging

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The University Hospital of Columbia and Cornell

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*As faculty of Weill Cornell Medical College  
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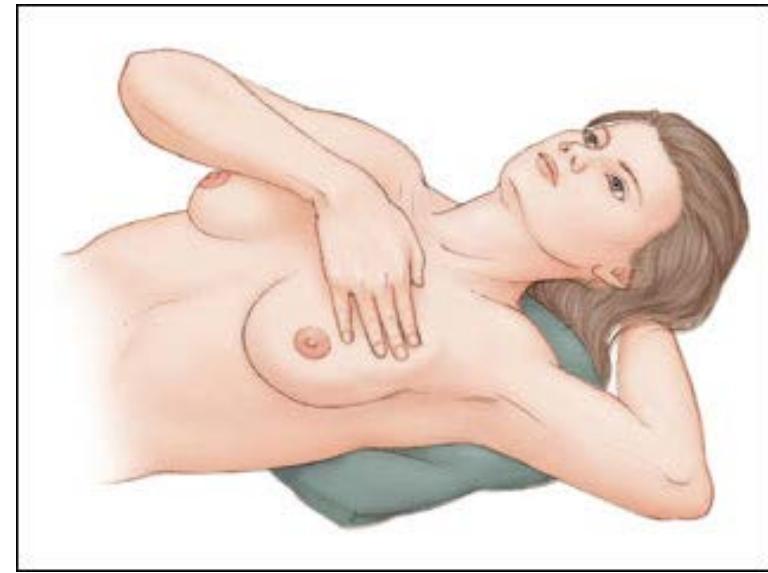
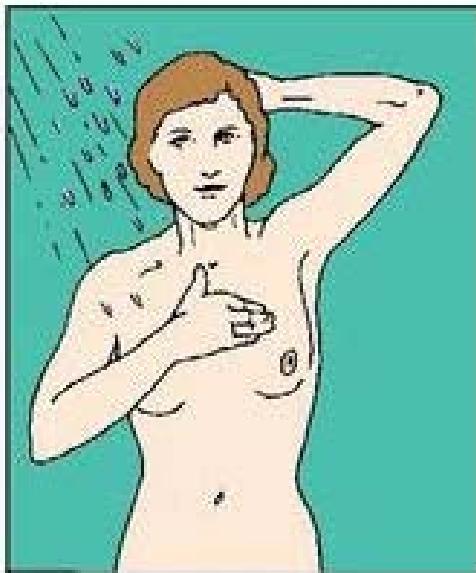
Consultant to McKinsey, Healthcare  
Analytics

# Session Core Objective

- By the end of the session, the learner (you) should be able to
  - Understand how imaging can screen and help diagnose breast and gyn malignancies
  - Consider how future technologies that might assist in this and understanding these diseases at a population based-level
  - State recommendations for breast cancer screening and basic evidence supporting the recommendations

# The Individual

- 44 year-old female feels a lump in her breast



# The Context



Centers for Disease Control and Prevention  
CDC 24/7: Saving Lives, Protecting People™

## Breast Cancer

### Breast Cancer

#### Basic Information



#### Breast Cancer in Young Women



#### Statistics



#### Rates by Race and Ethnicity

#### Rates by State

#### Risk by Age

#### Screening Rates

#### Trends

#### What CDC Is Doing



[CDC](#) > [Cancer Home](#) > [Breast Cancer](#)

### Breast Cancer Statistics



Not counting some kinds of skin cancer, breast cancer in the United States is—

- The most common cancer in women, no matter your race or ethnicity.
- The most common cause of death from cancer among Hispanic women.
- The second most common cause of death from cancer among white, black, Asian/Pacific Islander, and American Indian/Alaska Native women.

For more information, visit [Cancer Among Women](#).

In 2011 (the most recent year numbers are available)—

- 220,097 women and 2,078 men in the United States were diagnosed with breast cancer.\*†
- 40,931 women and 443 men in the United States died from breast cancer.\*†

# Individual

- She calls her doctor to ask her what to do – doctor given her a prescription for a mammogram

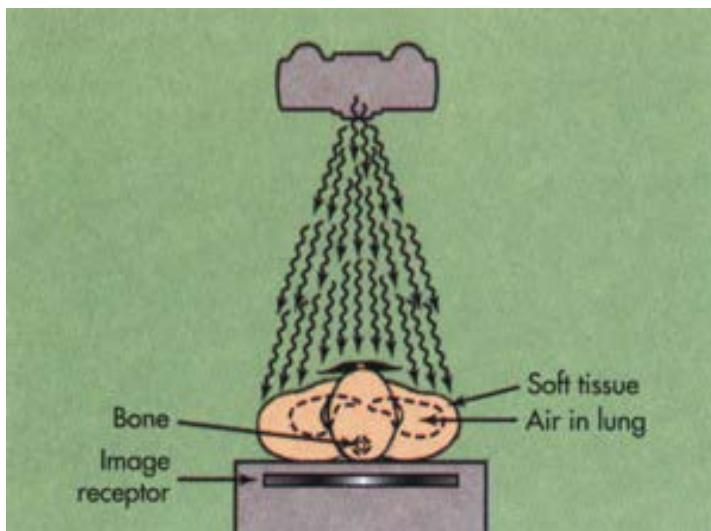


# Definition: mammogram types

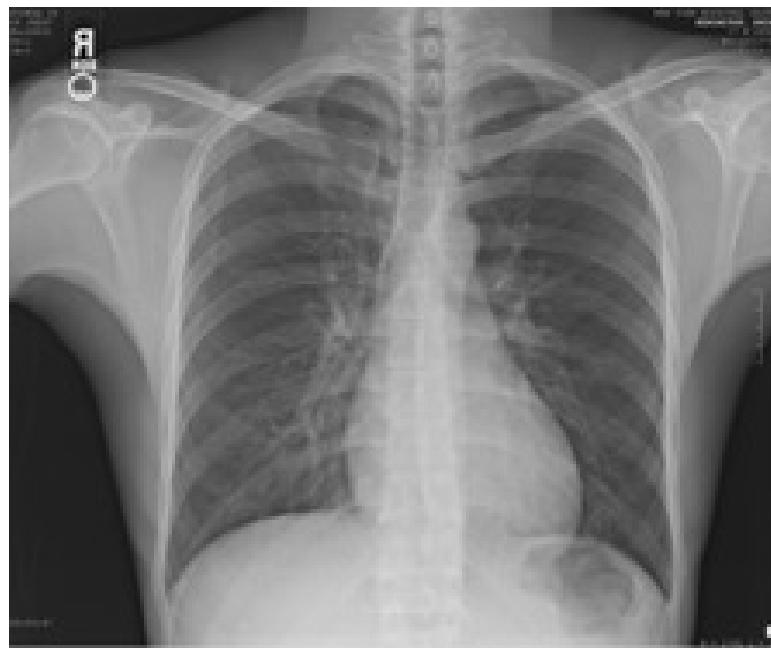
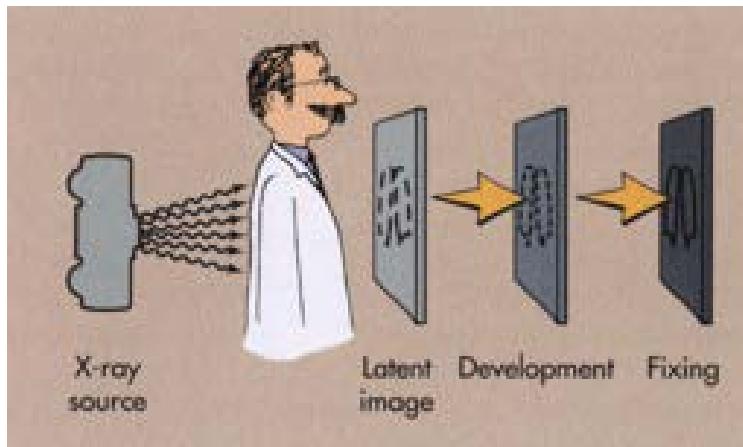
- Screening: asymptomatic, no personal history of breast cancer
- Diagnostic: symptomatic OR personal history of breast cancer

# Technology: X-ray

- Patient placed near film or digital image receptor
- Short burst of x-rays directed toward patient
- Shadow recorded on image receptor

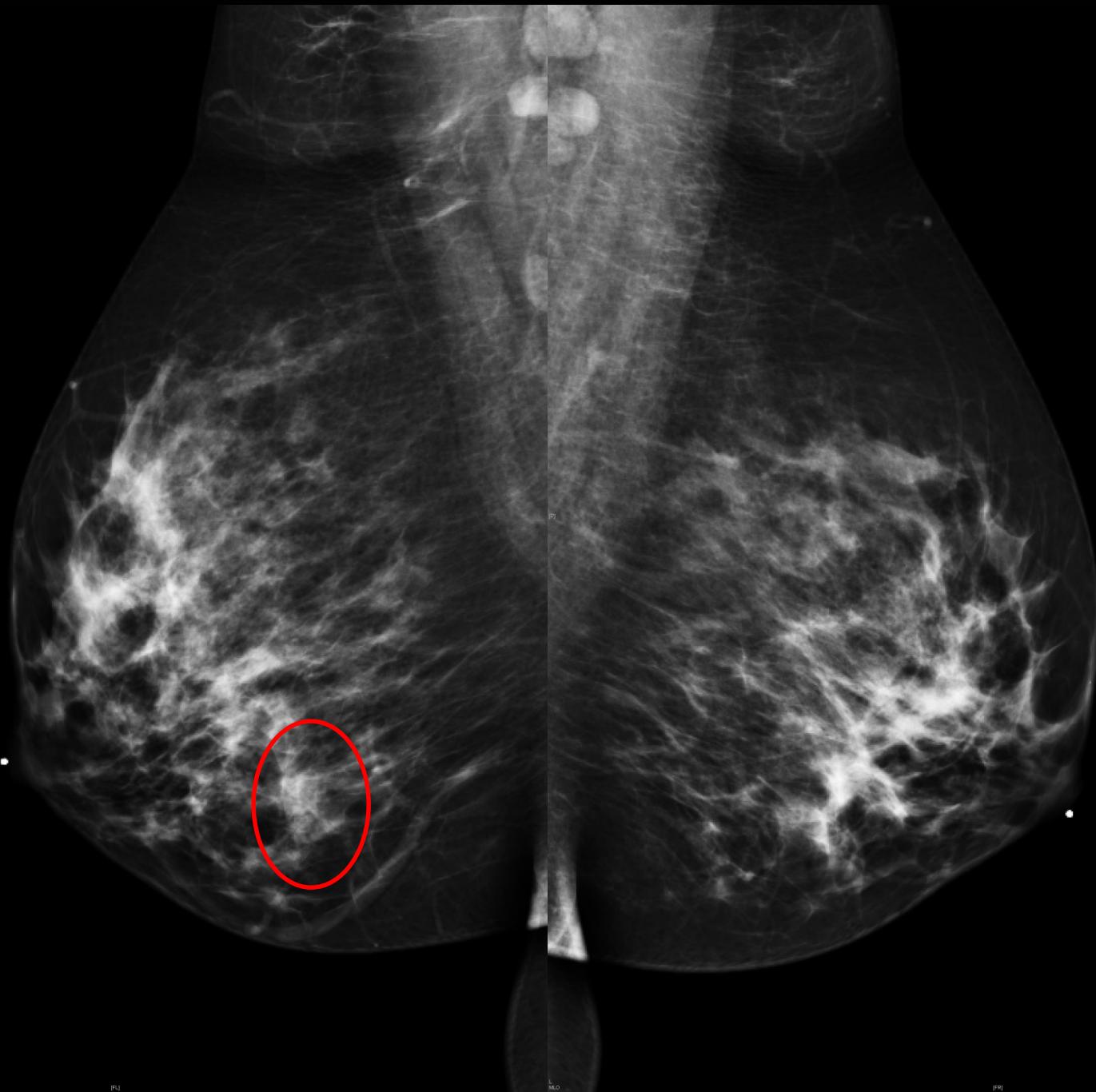


# Chest x-ray: Then & Now



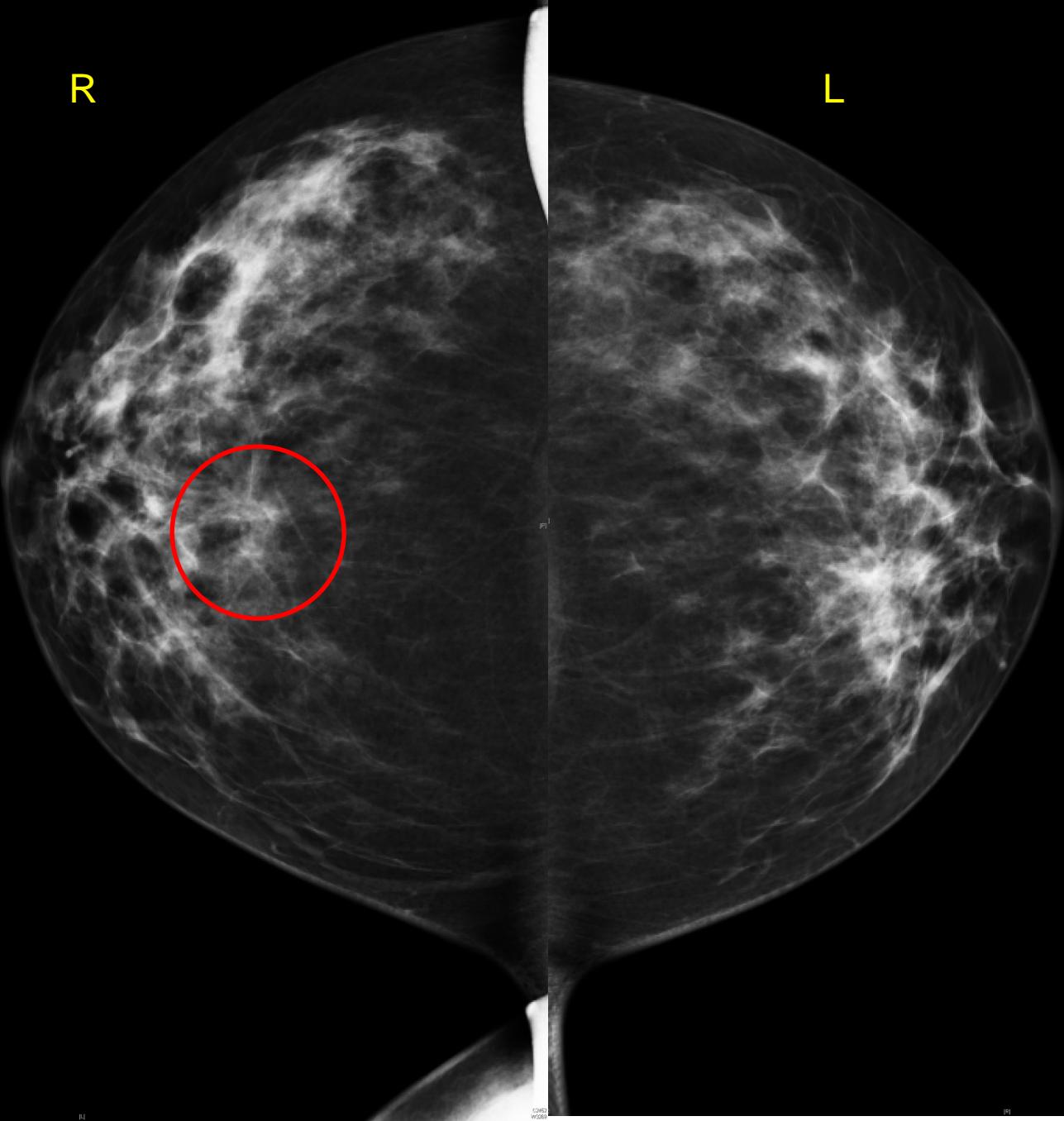
# Individual



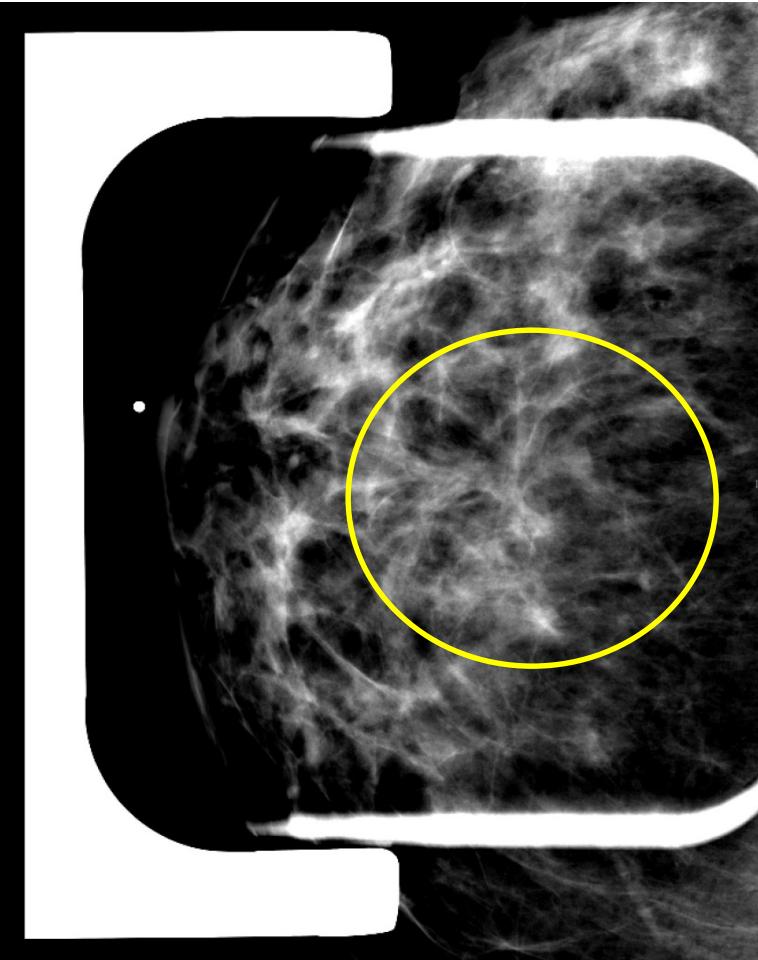


R

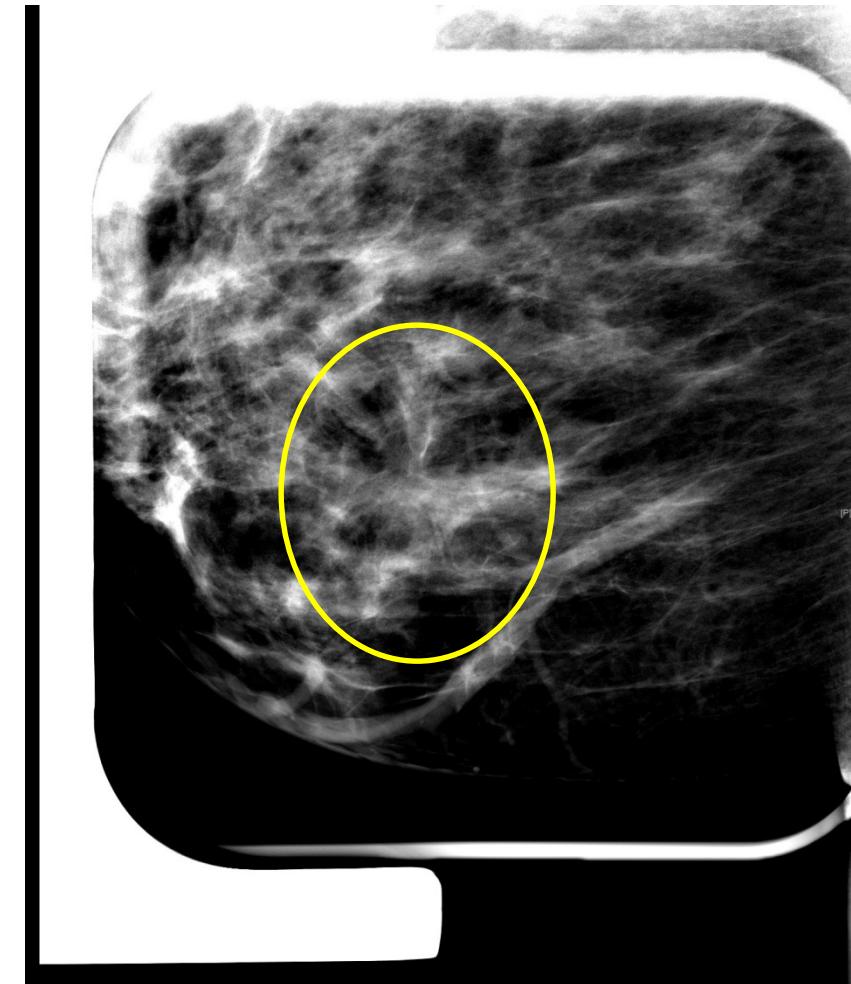
L



Right CC spot



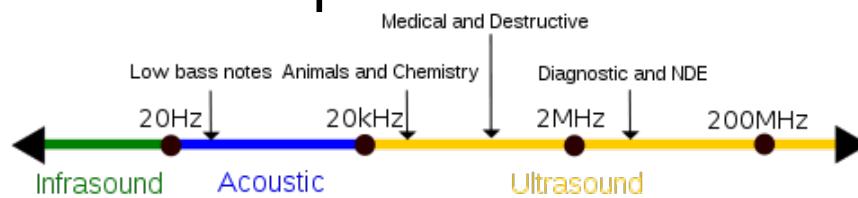
Right Spot ML



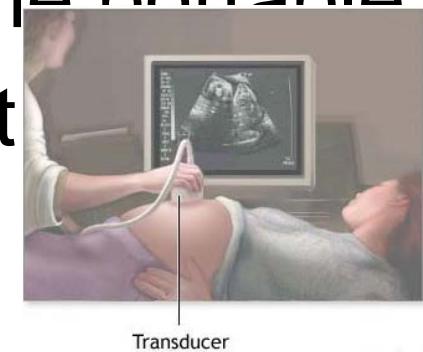


# Technology: Ultrasound (US)

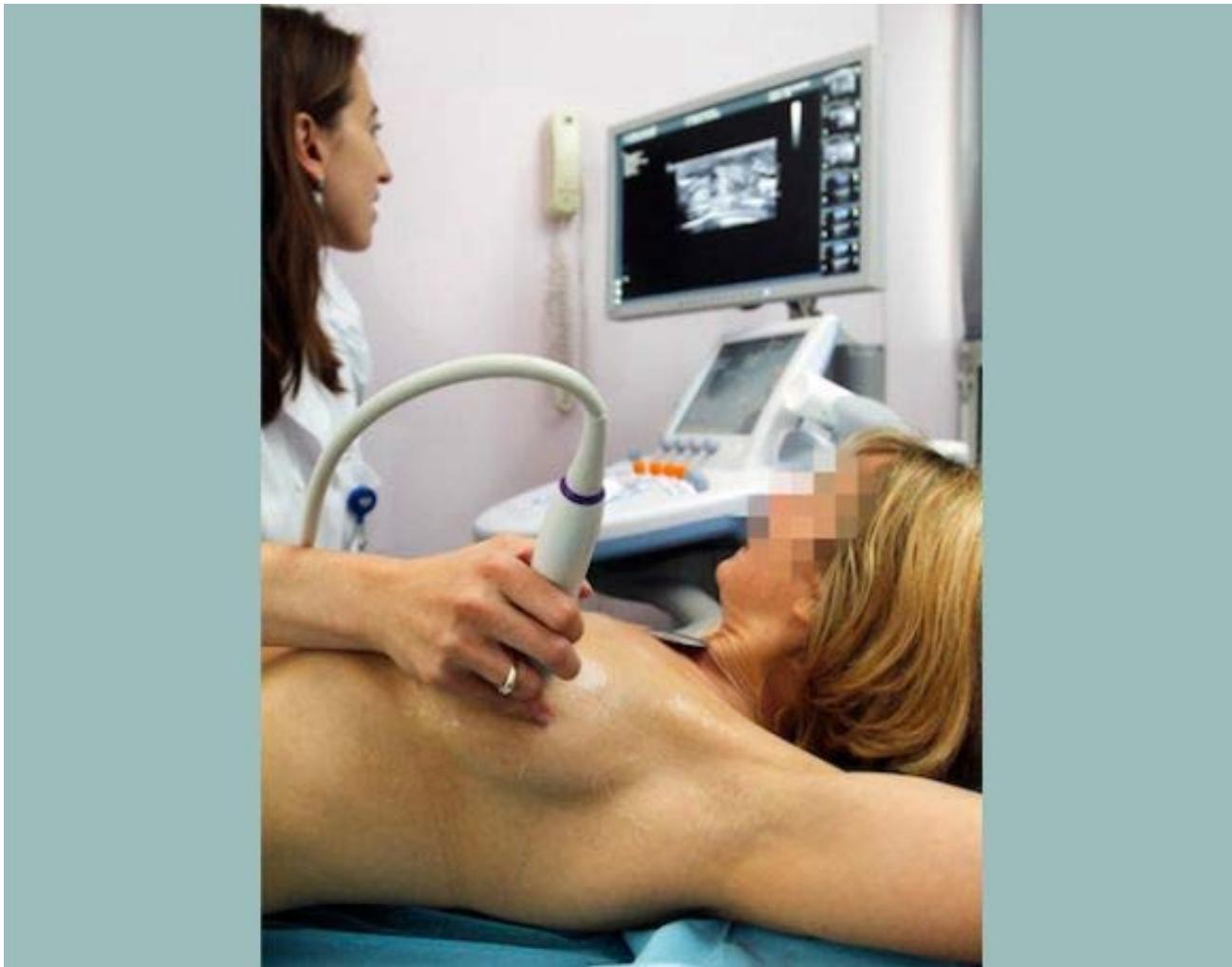
- Image production
  - Short sound pulses transmitted into body
  - Velocity of propagation constant for a given tissue
  - Orientation: depends on transducer angle



- Pros: no radiation, real-time portable
- Cons: operator dependent



# Individual

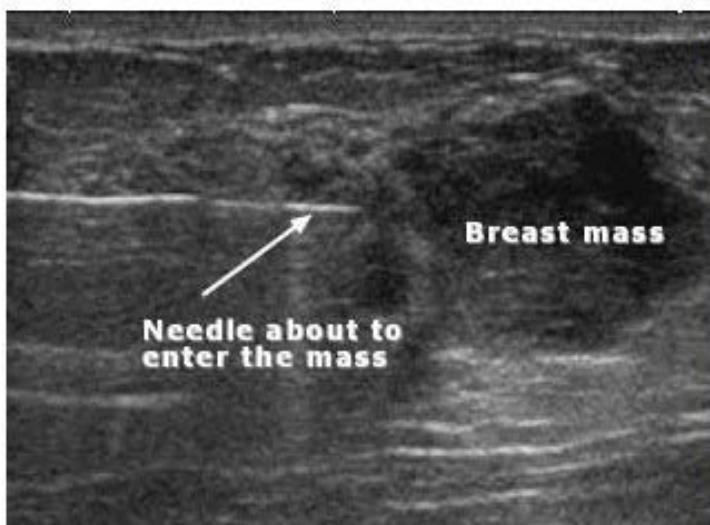
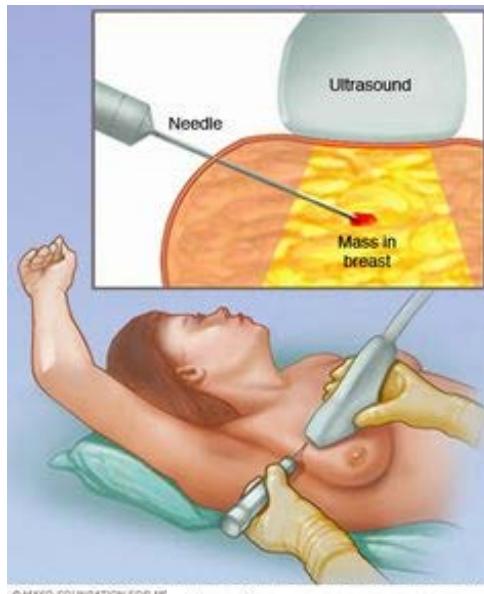




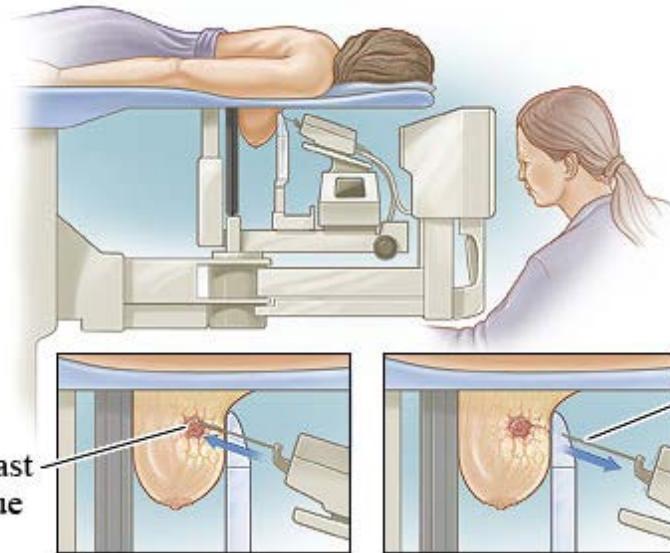
# Technology: Image-guided biopsy

- US-guided
- Mammo-guided = stereotactic biopsy
- MRI-guided

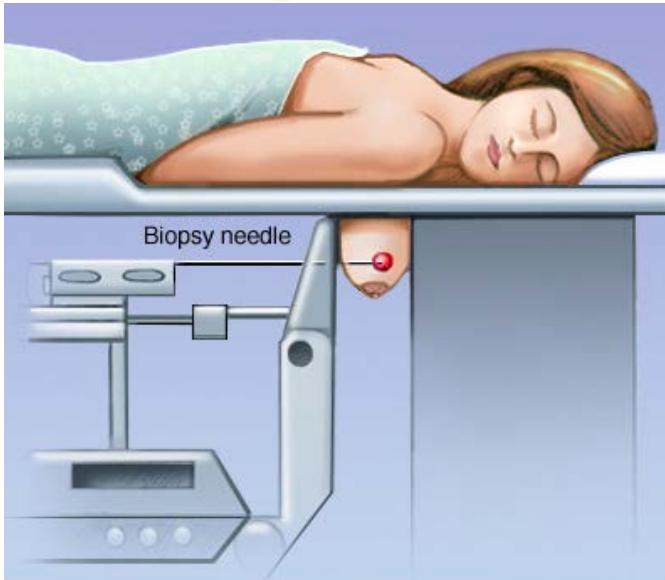
# US-guided core biopsy



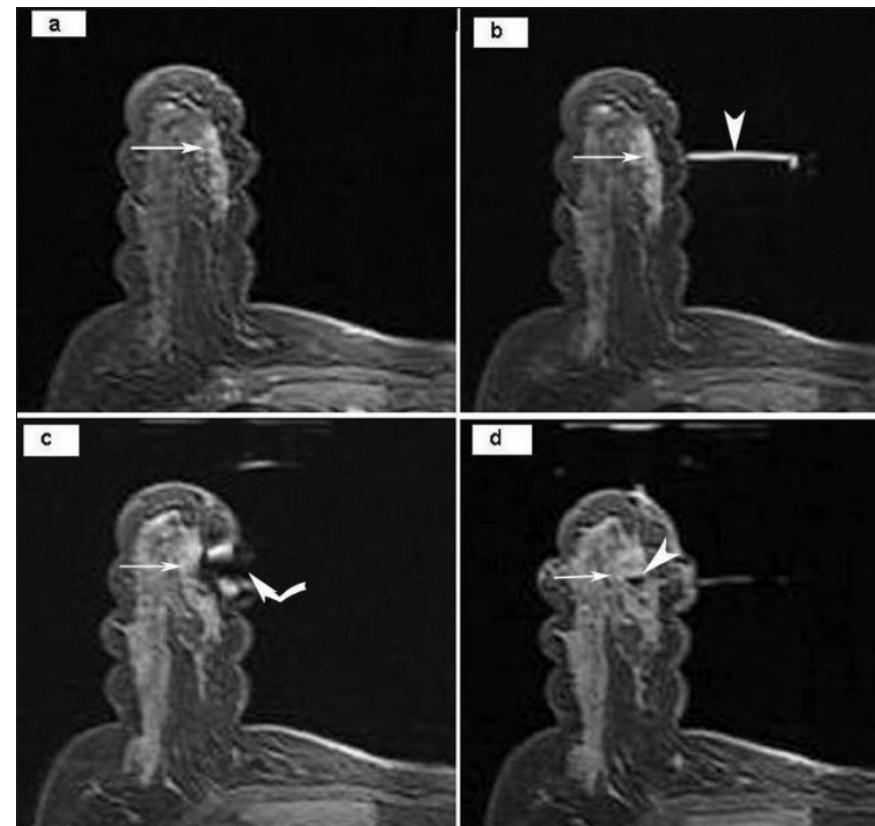
# Stereotactic core biopsy



# MRI-guided biopsy



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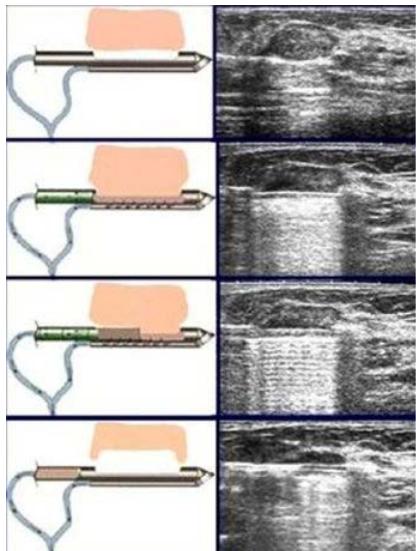
# Future technology?

- Some way of establishing benign vs. malignant without invasive procedure
  - Elastography
    - with US, maps the elastic properties of soft tissue
  - Spectroscopy
    - with MRI, measures chemical content of breast lesions
  - Molecular markers
  - Maybe something you invent!

# Individual



# Next step: Pathology



# Diagnosis

- Invasive ductal carcinoma
  - Grade II / moderately differentiated
  - ER/PR positive

# Diagnosis: Invasive ductal carcinoma

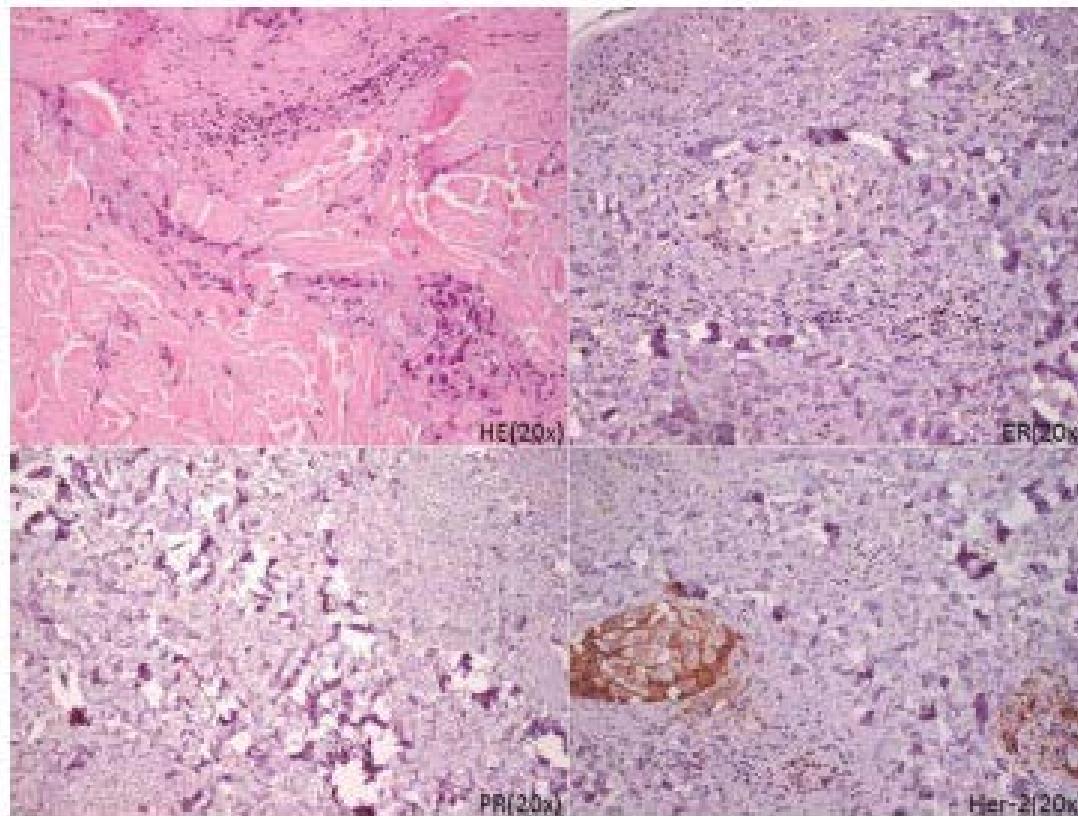


FIGURE 2: Histological features of the tumor. Hematoxylin-eosin showed a ductal carcinoma. The tumor was ER-negative, PR-negative and HER-2-positive (3+)

# Context: Types of Breast Cancers

- Sarcomas <1%
- Carcinomas >99%
  - In situ
  - Invasive
    - Invasive ductal 80%
    - Invasive lobular 10-15%
    - Other 5-10%
      - Mucinous), medullary, micropapillary, papillary, tubular

# Context: more path analysis

- Grade
  - 1-well differentiated
  - 2-moderately differentiated
  - 3-poorly differentiated
- Hormone receptors
  - Estrogen
  - Progesterone

*"If cancer cells have receptors for these hormones, it's not necessarily a bad thing. It means that they are at least TRYING to perform the tasks of a normal breast cell. They're behaving — somewhat."*

-- Marisa Weiss, M.D., president and founder, Breastcancer.org

# Technology: now & future

- erbB-2 (her2/neu)
- Ki67 protein
- Maybe something you find that can predict which breast cancers will be indolent and which will be aggressive

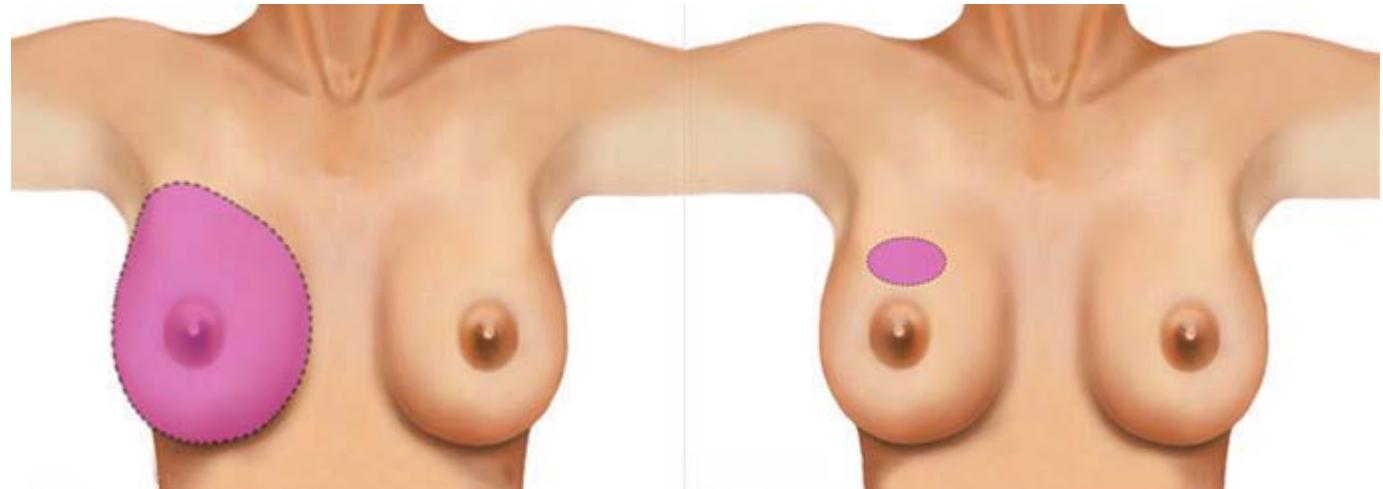
# Individual

- Radiologist or doctor calls with results and refers her
  - Breast surgeon
  - MRI
  - Genetic counselor
  - Gyn/onc
  - Oncologist

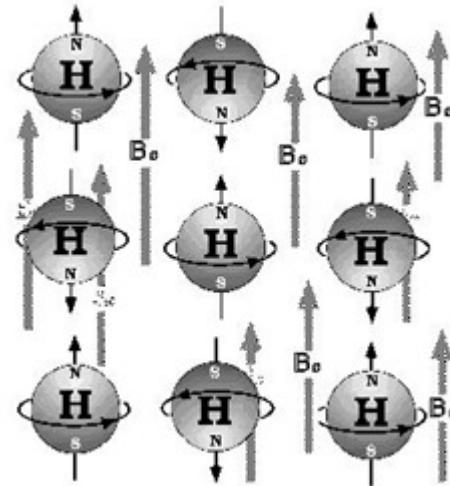
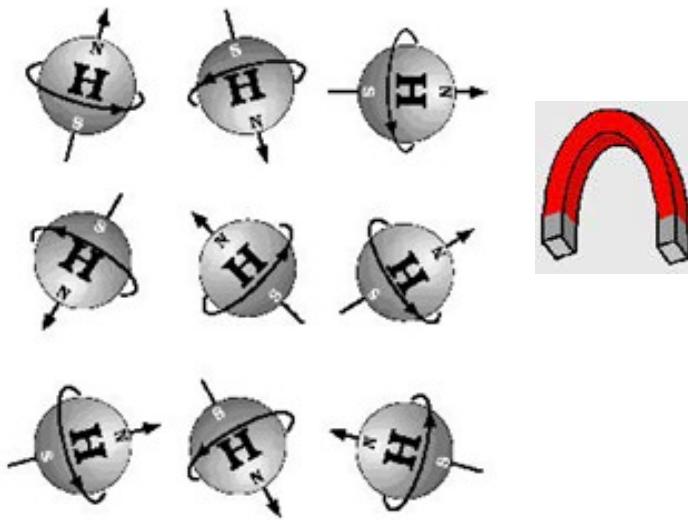


# Breast surgeon

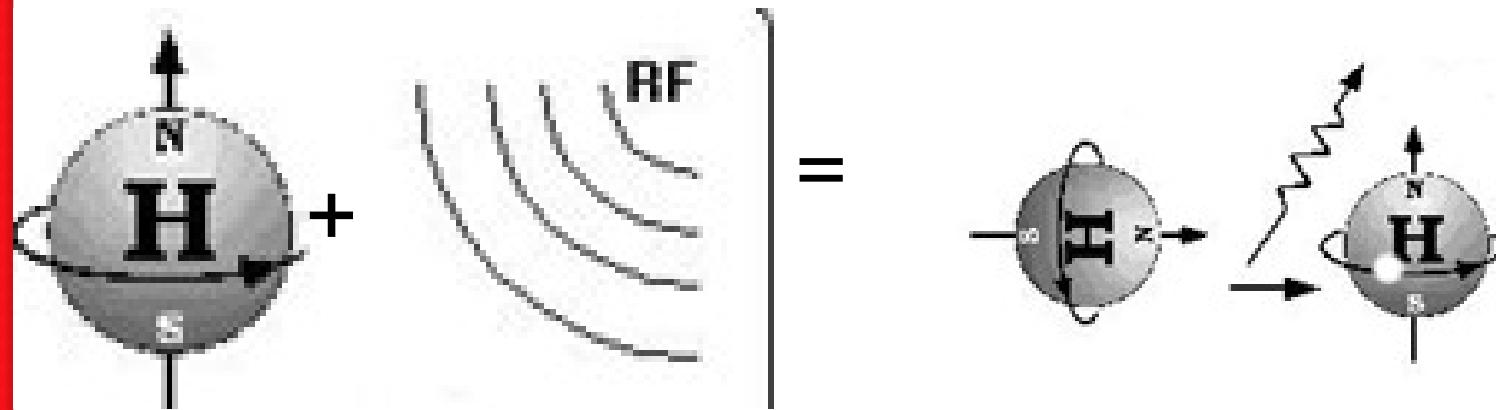
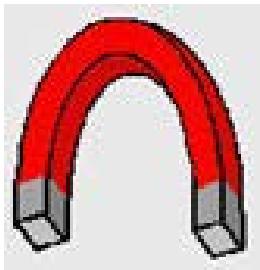
- Mastectomy vs. lumpectomy



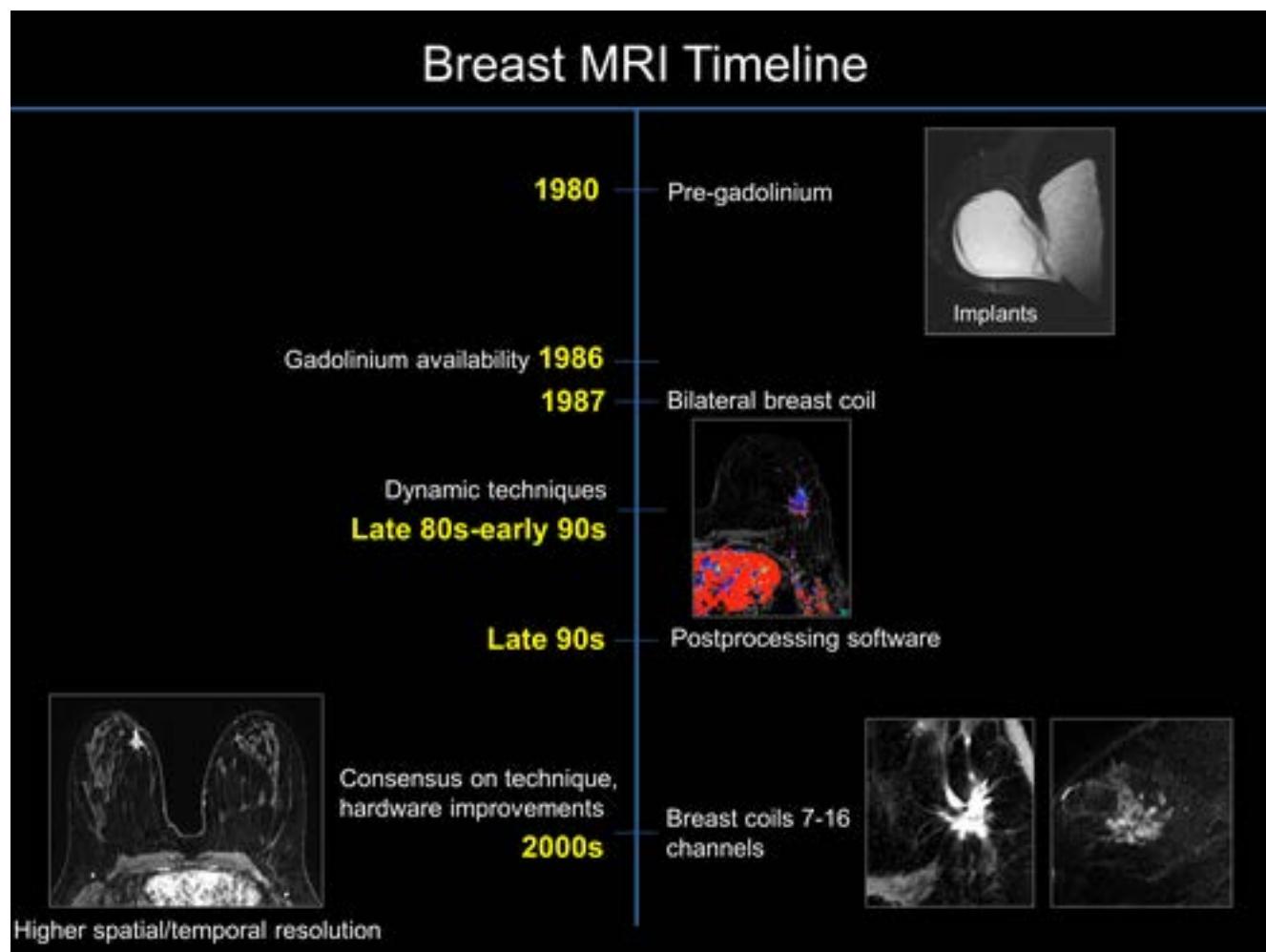
# Technology: Magnetic Resonance Imaging (MRI)



# Image production: MRI



# Technology: Make the future



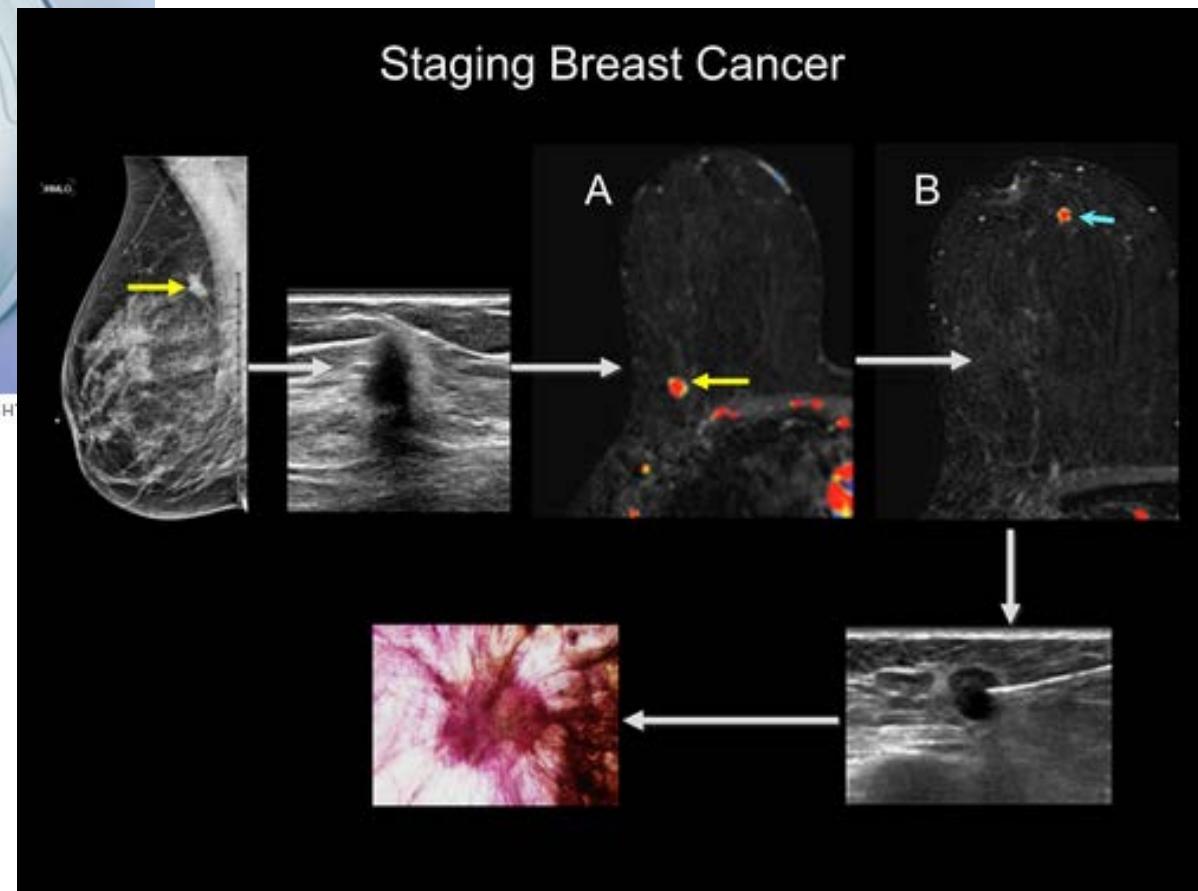
Slide courtesy of Gillian Newstead, MD

# Individual



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Slide courtesy of Gillian Newstead, MD



# Individual

- Radiologist or doctor calls with results and refers her
  - Breast surgeon
  - MRI
  - **Genetic counselor**
  - Gyn/onc
  - Oncologist

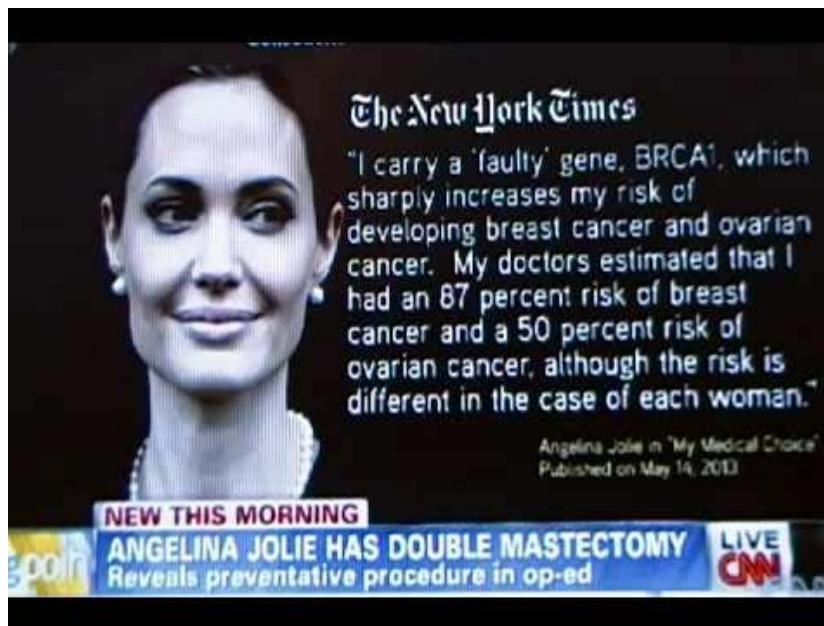
# Context

- National Comprehensive Cancer Network (NCCN) Guidelines for BRCA testing for Hereditary Breast and/or Ovarian Syndrome:
  - genetic testing for any breast cancer patient diagnosed at 45 years of age or younger

# Definition: BRCA

	Breast cancer risk	Ovarian cancer risk
BRCA 1	85%	40-50%
BRCA 2	85%	27%

Source:  
Cardenosa G.  
Breast Imaging  
Companion, 3<sup>rd</sup>  
edition





The Opinion Pages | OP-ED CONTRIBUTOR

## Angelina Jolie Pitt: Diary of a Surgery

By ANGELINA JOLIE PITT MARCH 24, 2015



Angelina Jolie Pitt Luke MacGregor/Reuters

had the option of removing my ovaries and fallopian tubes and I chose to do it.

# Individual

- Radiologist or doctor calls with results and refers her
  - Breast surgeon
  - MRI
  - Genetic counselor
  - **Gyn/onc**
  - Oncologist

# Gyn/onc

- Prophylactic removal of ovaries?
  - If yes, then HRT needed to address abrupt surgical menopause
  - If no, then regular pelvic US surveillance



preventive double [mastectomy](#). A simple blood test had revealed that I carried a mutation in the BRCA1 gene. It gave me an estimated 87 percent risk of [breast cancer](#) and a 50 percent risk of [ovarian cancer](#). I lost my mother, grandmother and aunt to [cancer](#).

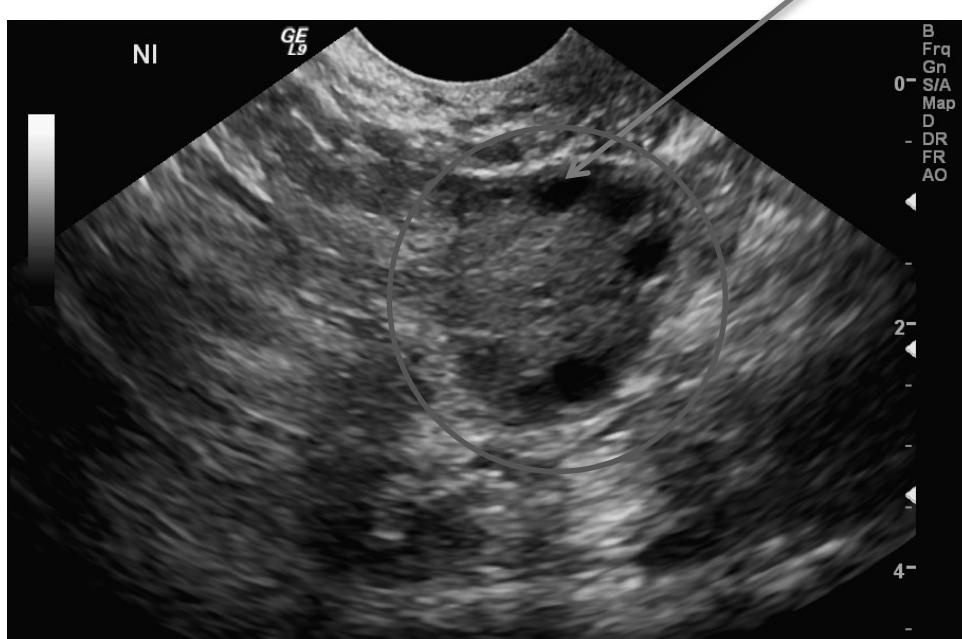
I wanted other women at risk to know about the options. I promised to follow up with any information that could be useful, including about my next preventive surgery, the removal of my ovaries and fallopian tubes.

I had been planning this for some time. It is a less complex surgery than the mastectomy, but its effects are more severe. It puts a woman into forced [menopause](#). So I was readying myself physically and emotionally, discussing options with doctors, researching [alternative medicine](#), and mapping my hormones for [estrogen](#) or [progesterone](#) replacement. But I felt I still had months to make the date.

# Technology: pelvic US

- Ovaries: evaluate for suspicious cystic/solid masses
- Uterus: baseline of endometrium prior to potential hormonal therapy

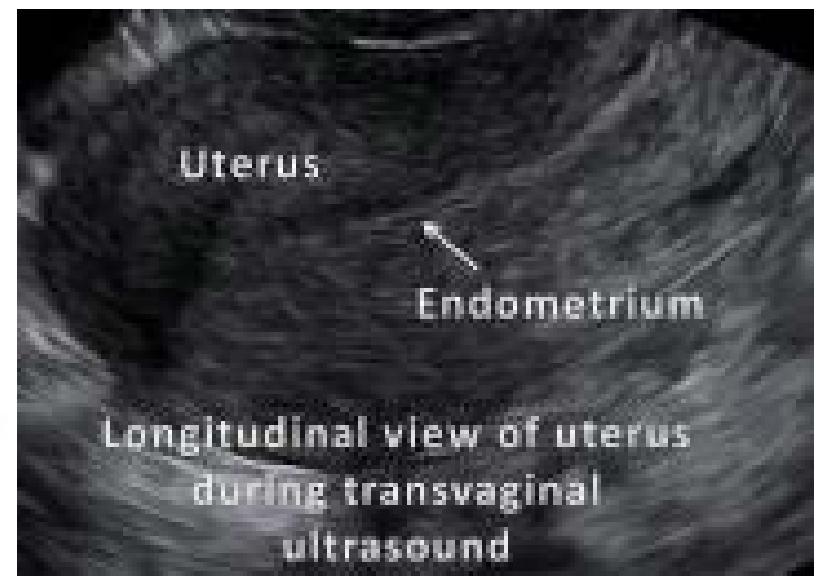
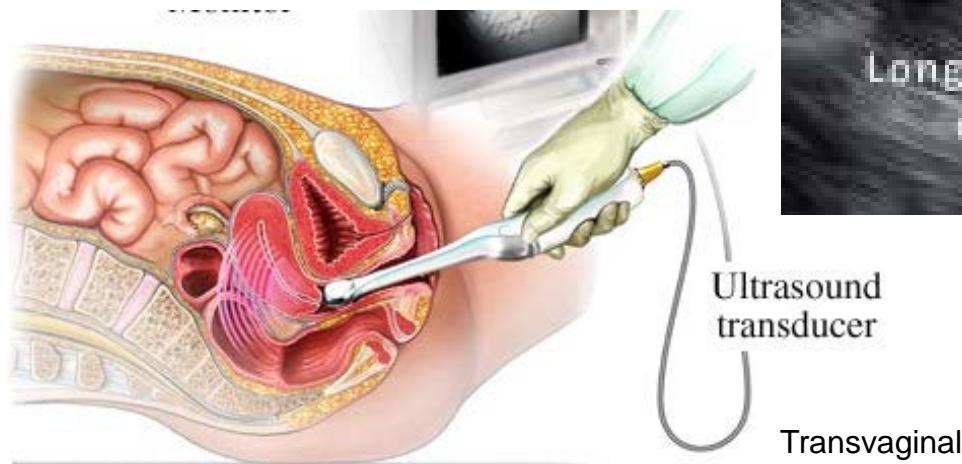
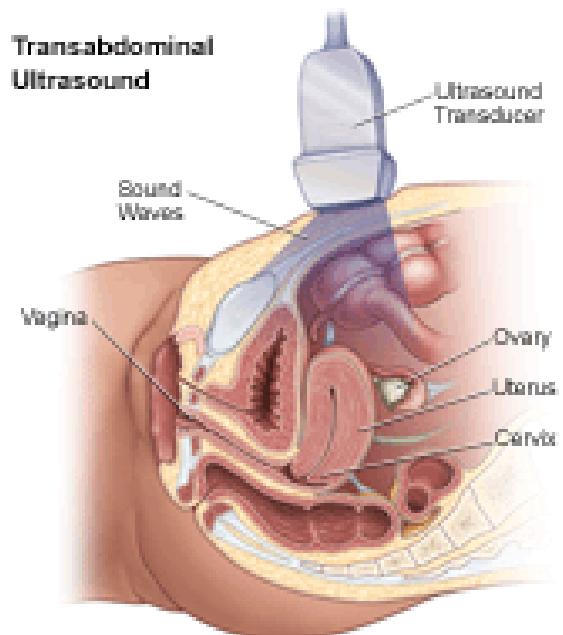
# Pelvic US: Ovaries



Follicles / “eggs”



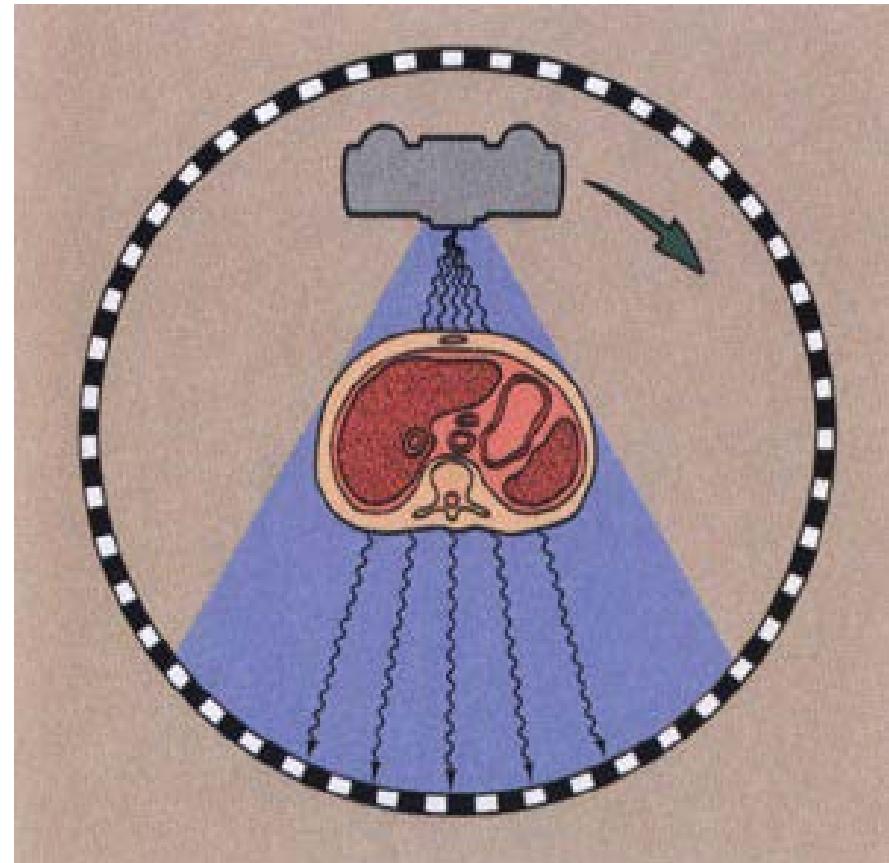
# Pelvic US: Uterus



# Individual

- Radiologist or doctor calls with results and refers her
  - Breast surgeon
  - MRI
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  - Gyn/onc
  - **Oncologist**

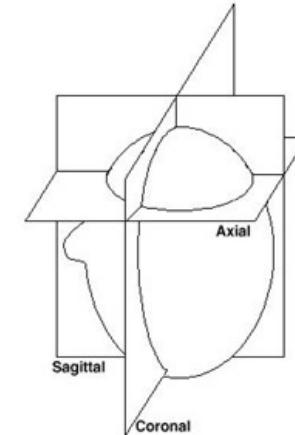
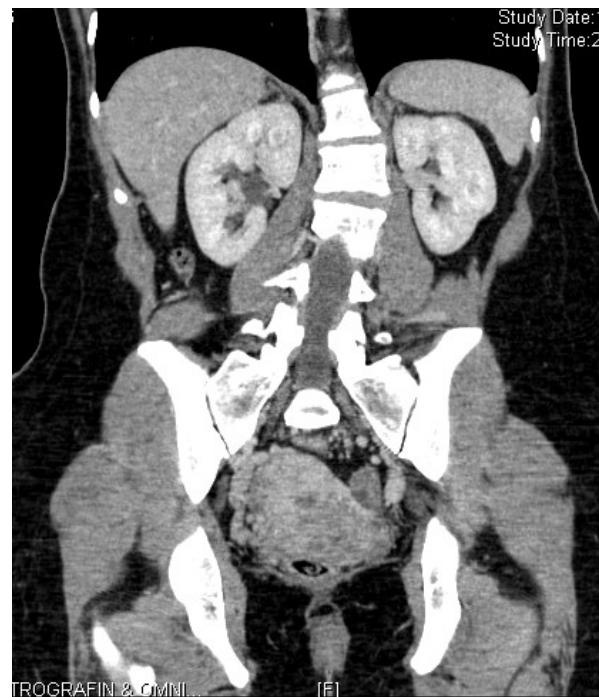
# Technology: Computed Tomography (CT)



Con: radiation (IV contrast)  
Pros: fast cross-sectional imaging, post-processing capabilities

# Technology: CT - multiplanar

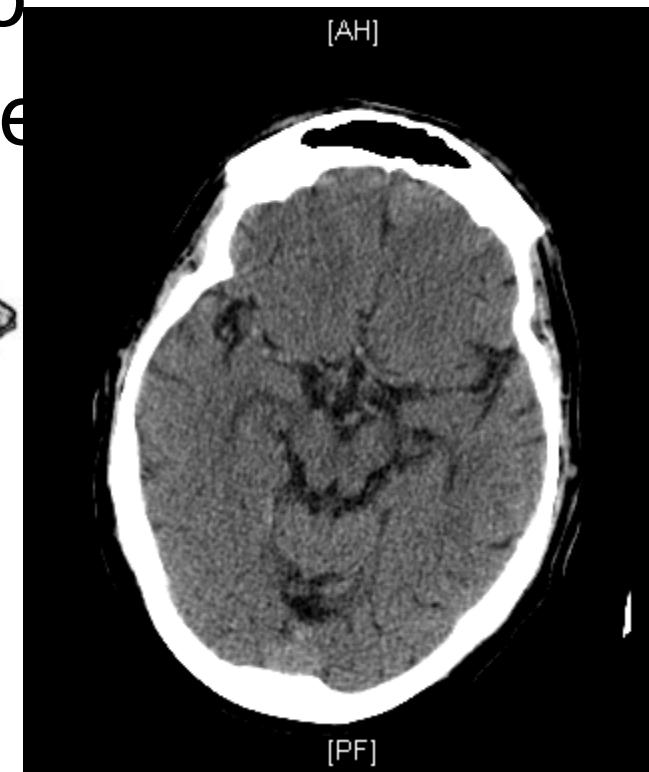
- Standard planes
  - Axial (transverse)
  - Sagittal (side)
  - Coronal (frontal)



Axial, coronal and sagittal slices

# Technology: CT - slice creation

- Each slice is a 2-d image, but a stack of slices gives 3-d info
- Axial (transverse) slices



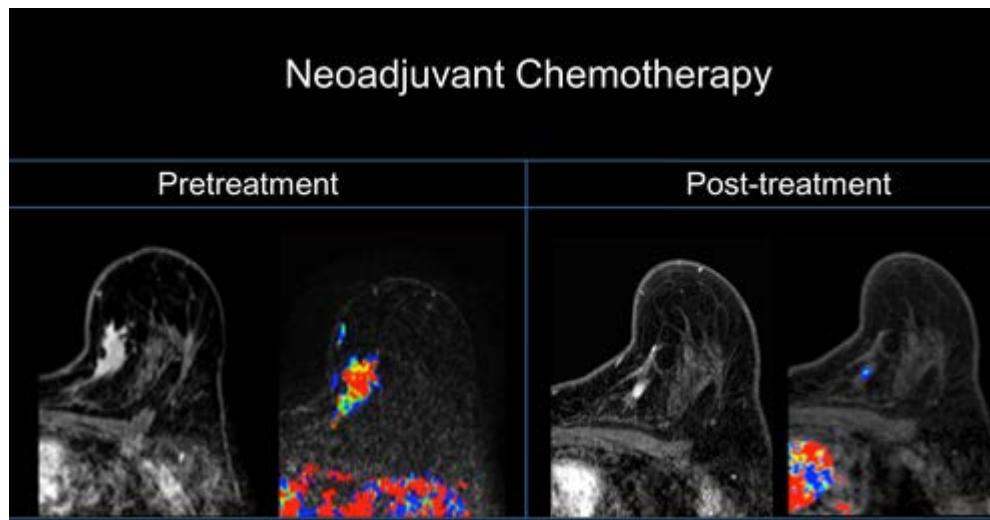
# Technology: CT - windowing

- Same image displayed with different “Window Widths” and “Window Levels”
  - Lung, bone & soft tissue windows



# Oncology

- Adjuvant therapy: applied AFTER initial treatment (surgery)
  - Radiation
  - Systemic therapy
    - Chemotherapy
    - Hormone therapy
- Neoadjuvant therapy applied BEFORE the main treatment
  - Example: neoadjuvant chemotherapy to tumor size preop



Images courtesy of  
Gillian Newstead, MD

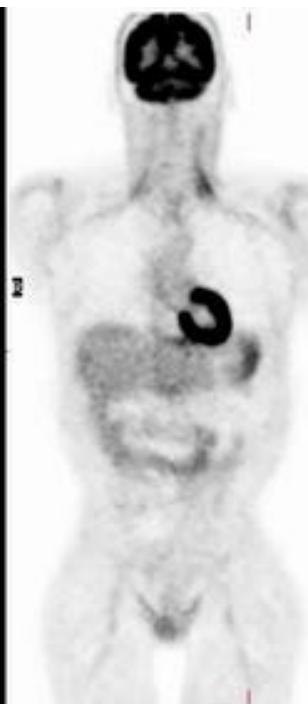
# Technology: PET-CT

Positron emission tomography (PET)–computed tomography

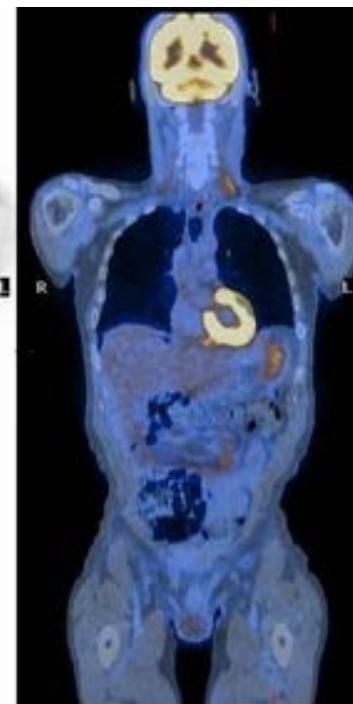
- Radioactive fluorine 18 to trace glucose metabolism (using fluorodeoxyglucose, FDG) --> “FDG-PET”



CT Transmission Scan

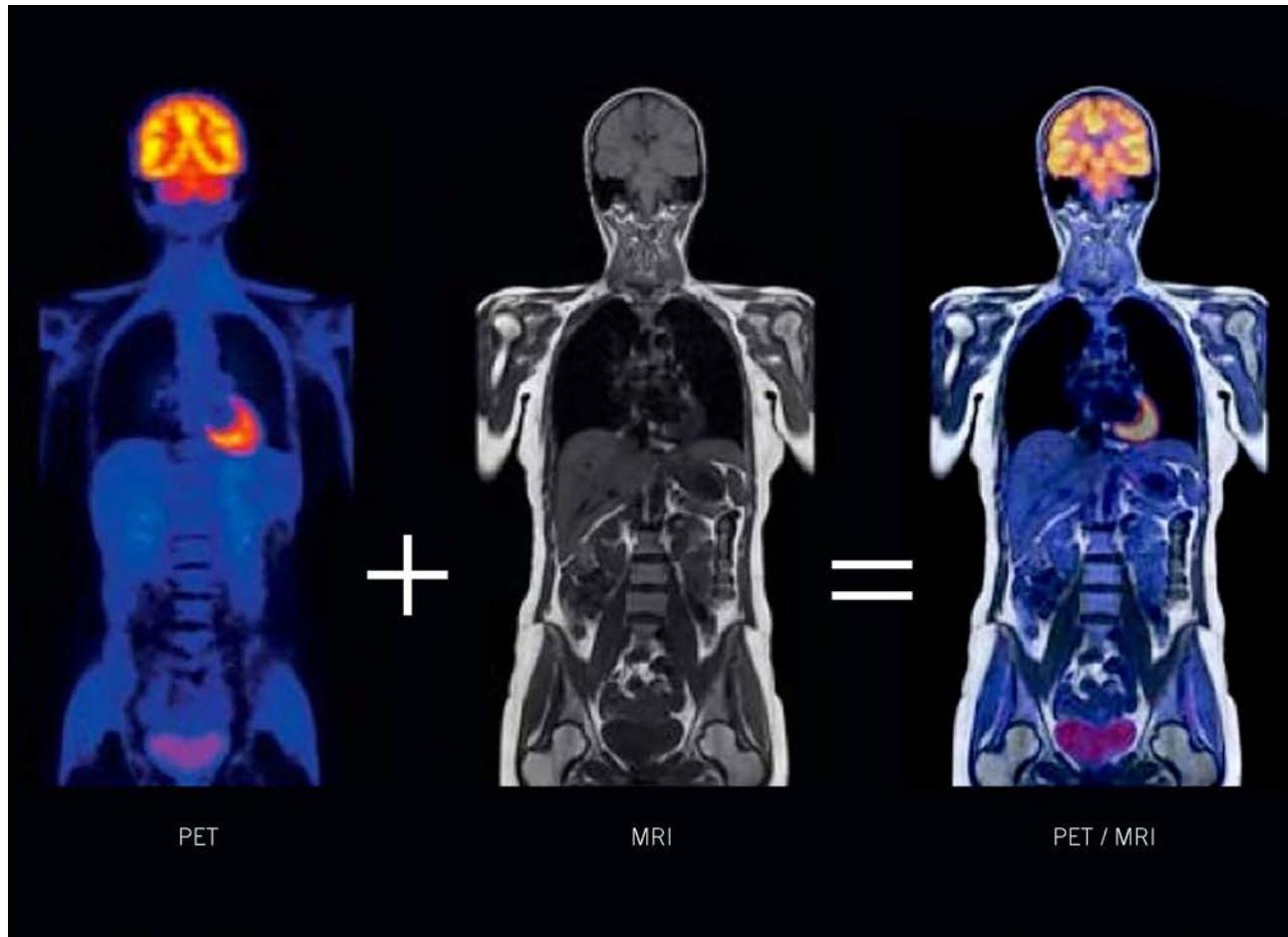


Attenuation Corrected PET Emission Scan



PET-CT Fusion Scan

# Technology: the future is now



# Individual: Recap

- Biopsy-proven invasive ductal carcinoma with MRI demonstrating multicentric disease & BRCA
  - Decision is made to have b/l mastectomy with immediate reconstruction

# Technology: plastic surgery

- Breast reconstruction options
  - Autologous
    - DIEP (Deep Inferior Epigastric Perforator) flap
    - Latissimus dorsi flap
    - TRAM (transverse rectus abdominus muscle) flap
  - Implant
    - Saline
    - Silicone

# Before and Afters

DIEP Flap



Before

After—1 yr later

Latissimus Flap



Before

After—1 yr later

Tissue Expander



Before

After—2 yrs later

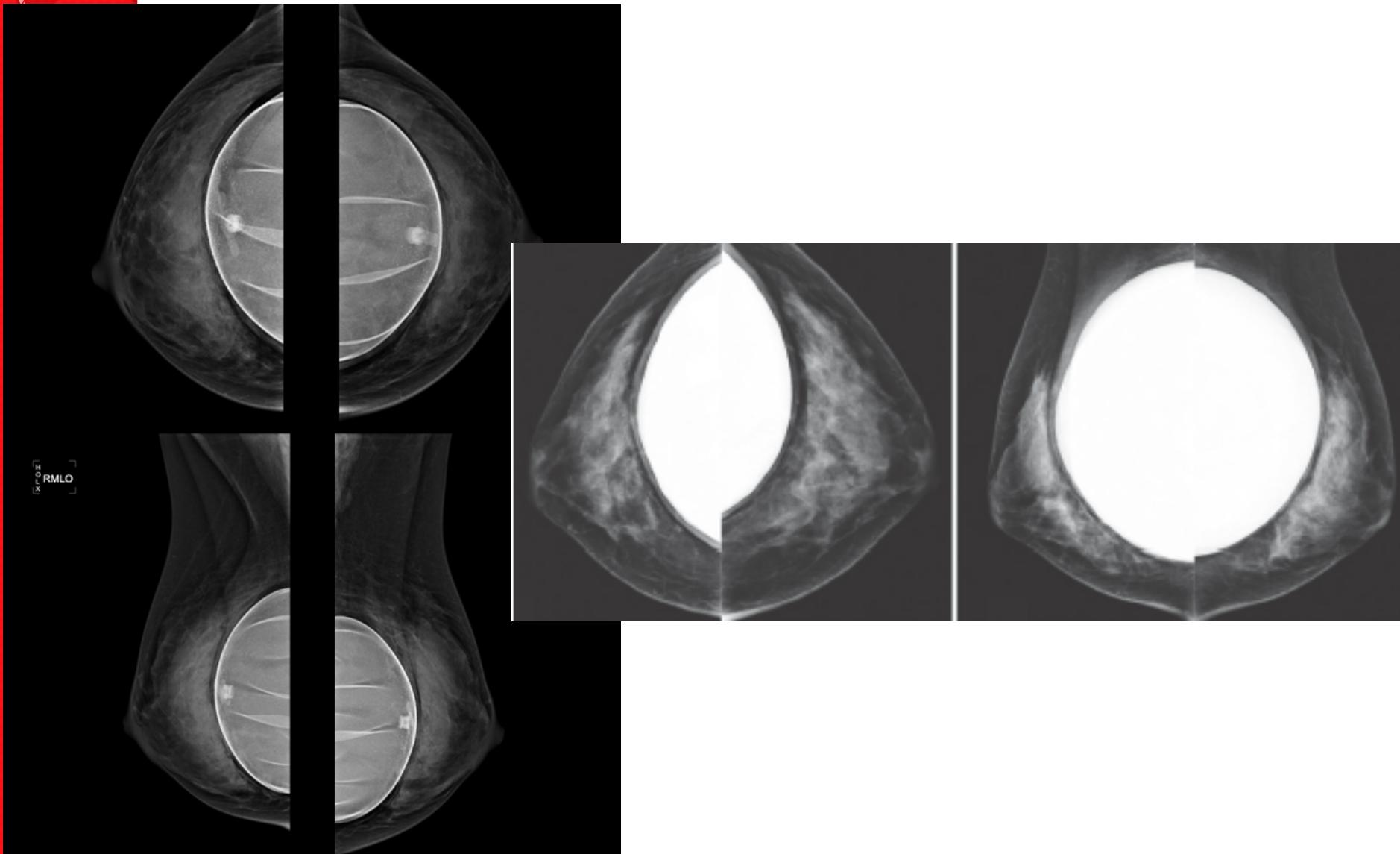
TRAM Flap



Before

After—1 yr later

# Saline vs silicone implants



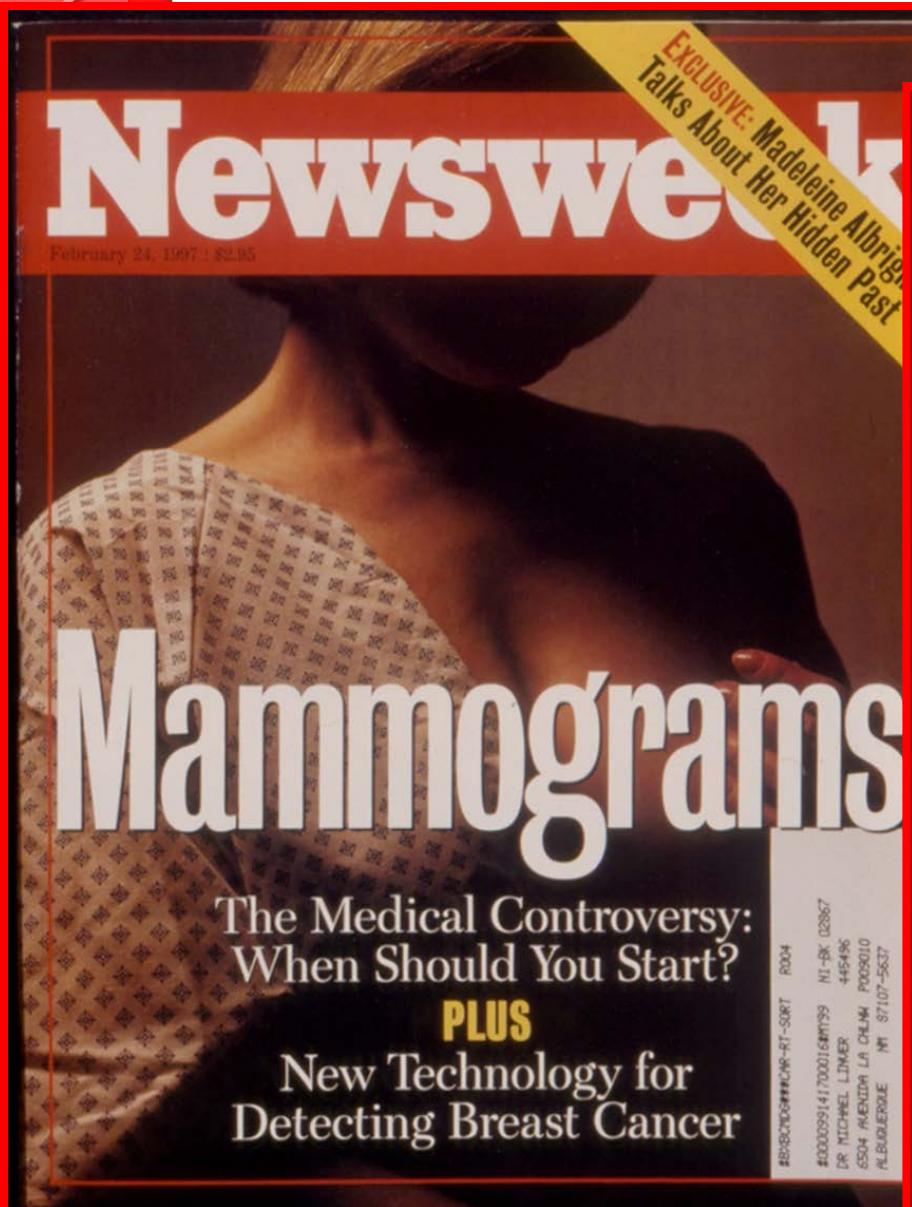
# Individual

- Admission
- OR
- Recovery
- Follow-up

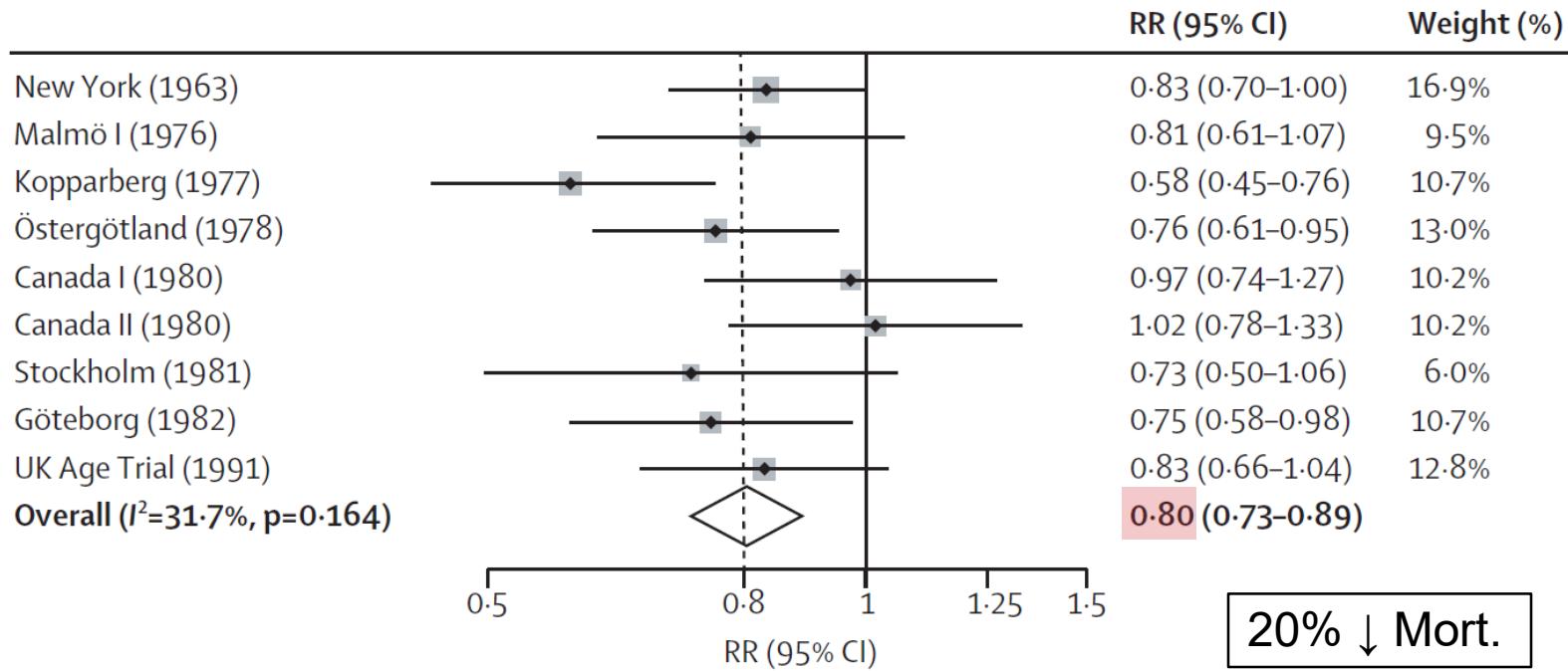


# Definition: mammogram types

- Screening: asymptomatic, no personal history of breast cancer
- Diagnostic: symptomatic OR personal history of breast cancer



# RCT Evidence (Ages 40-69)



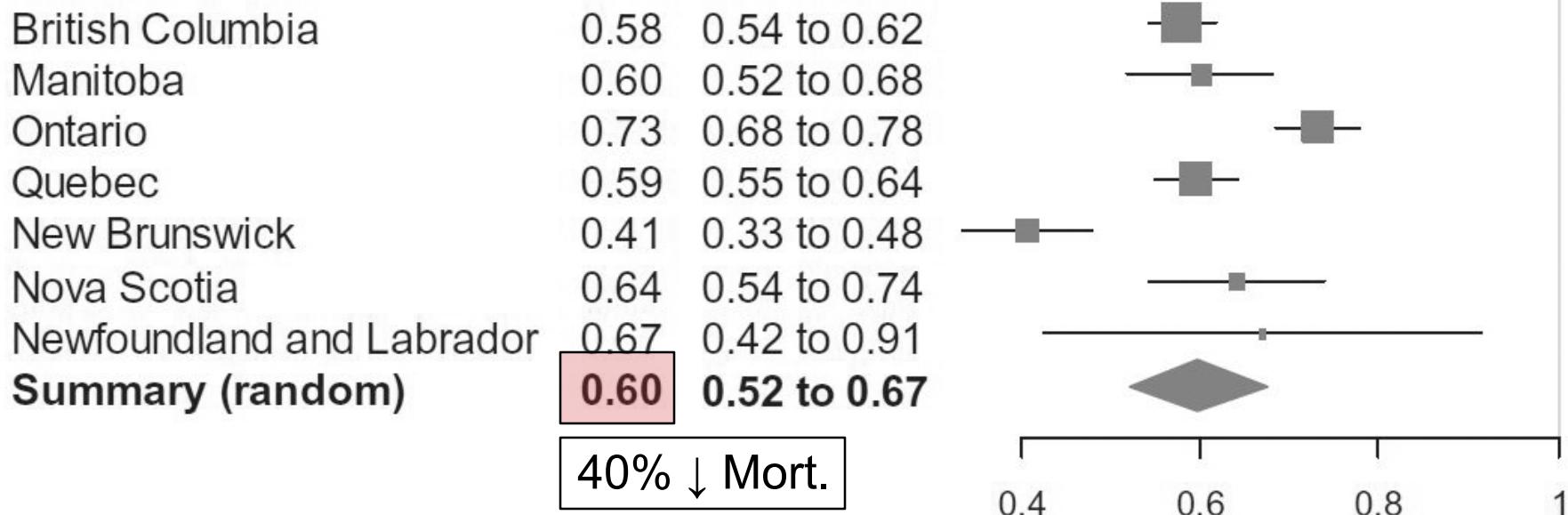
**Relative risk = 0.80 (0.73-0.89)**

Lancet 2012; 380:1778-1786

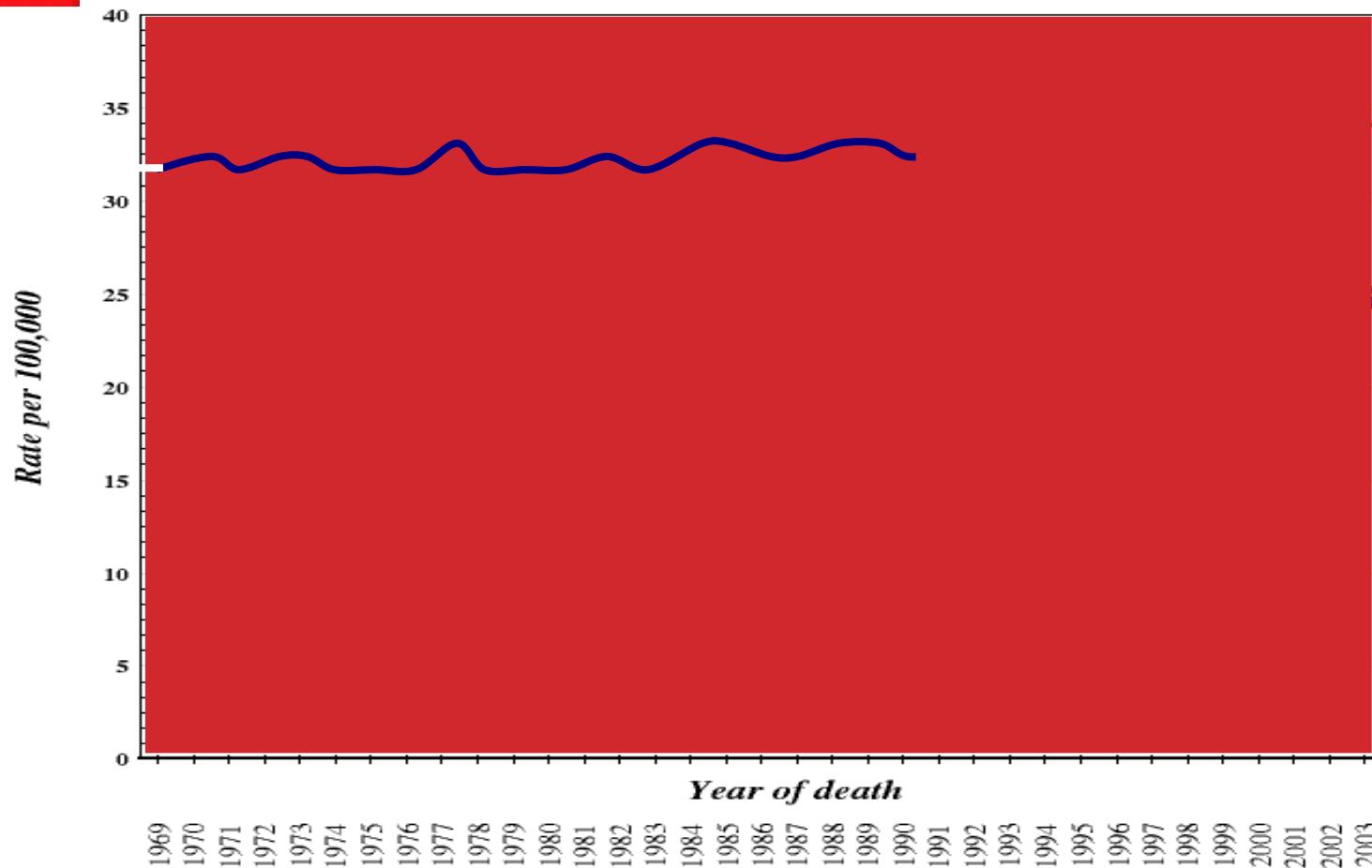
# Canada Service Screening (Ages 40-79)

## Region

## SMR 95% CI

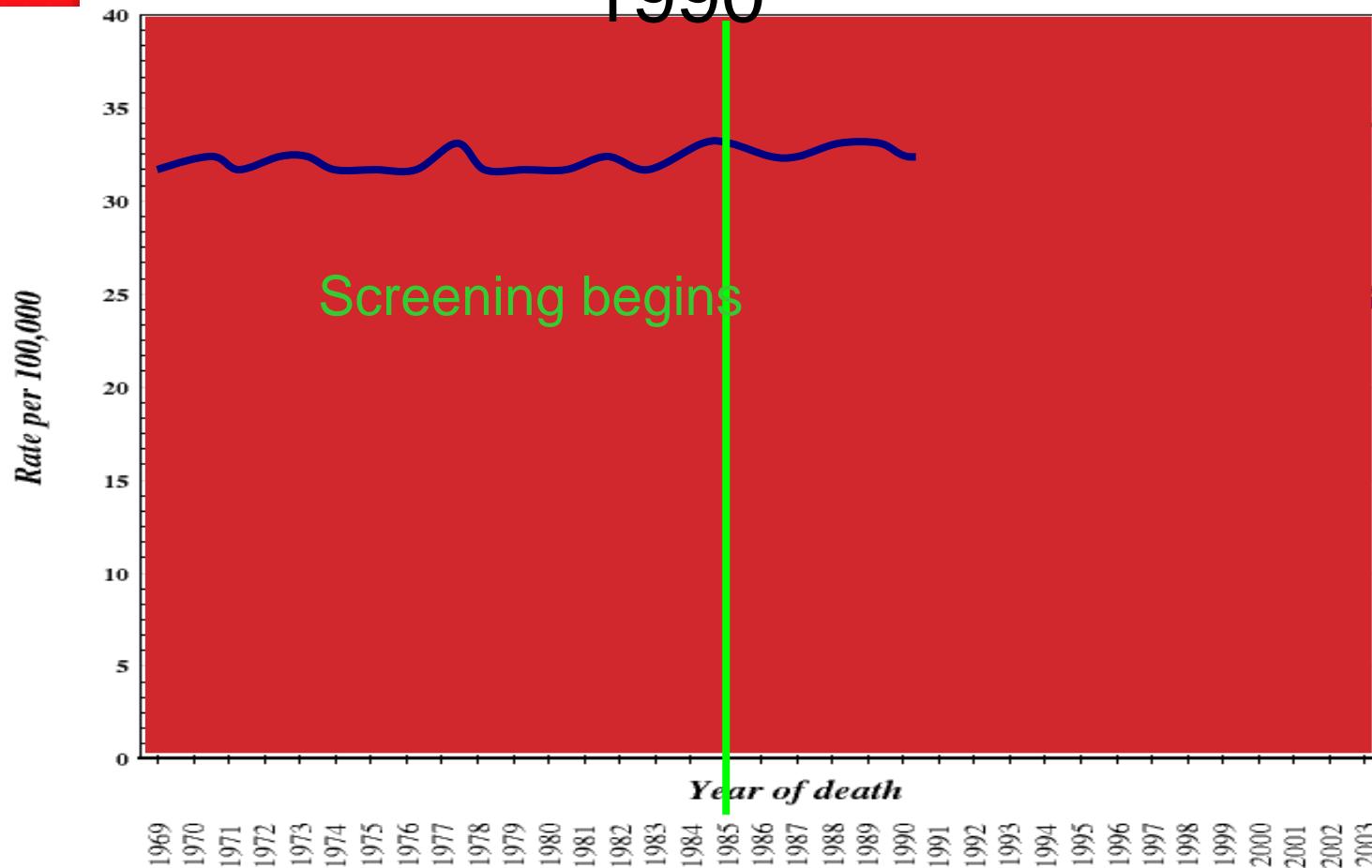


# Breast Cancer Death Rate 1969-1990



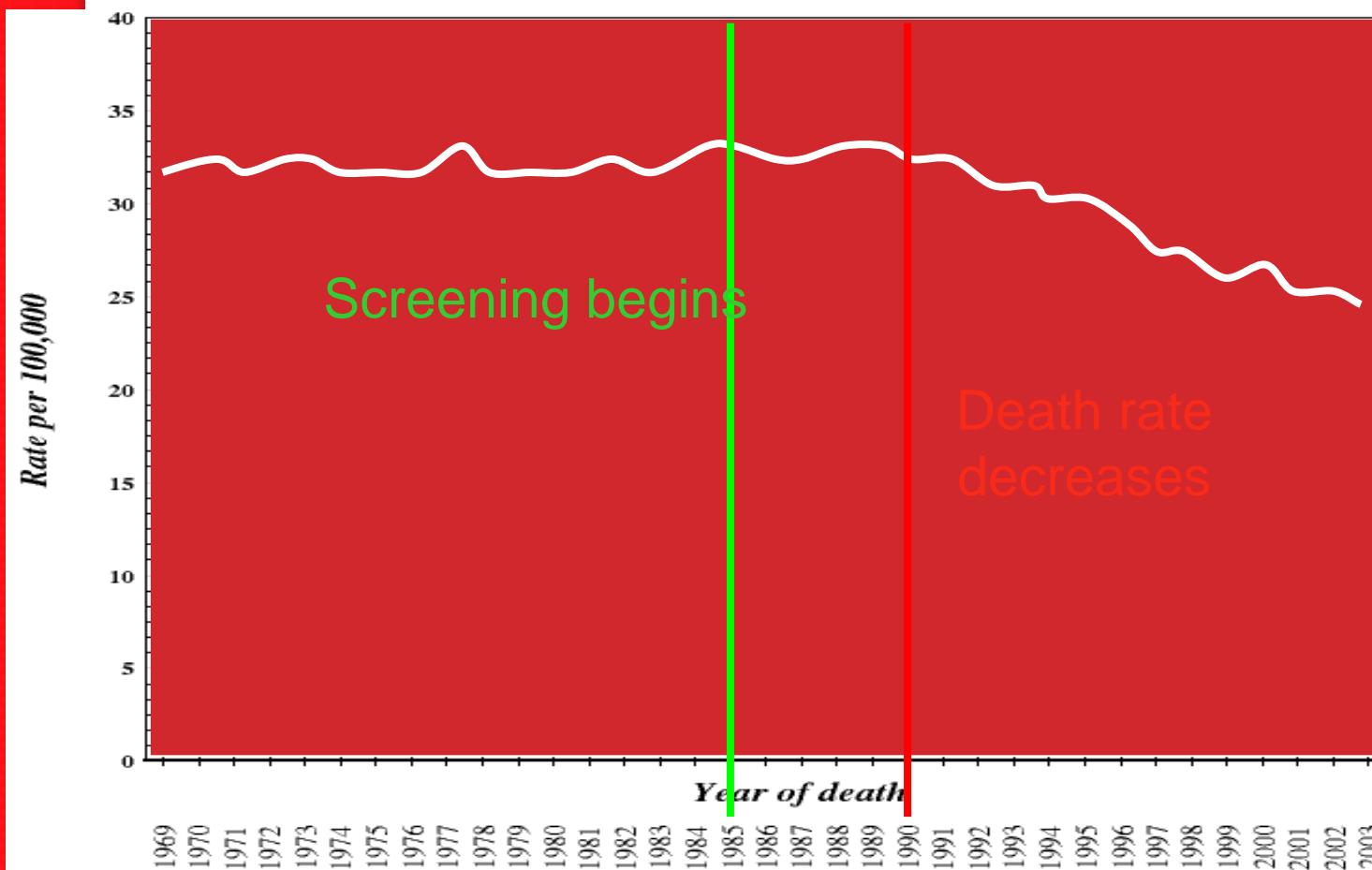
Surveillance, Epidemiology, and End Results (SEER) Program  
([www.seer.cancer.gov](http://www.seer.cancer.gov)) SEER\*Stat Database: Mortality - All COD, Public-Use With State, Total U.S. (1969-2003), National Cancer Institute, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 2006. Underlying mortality data provided by NCHS ([www.cdc.gov/nchs](http://www.cdc.gov/nchs))

# Breast Cancer Death Rate 1969-1990



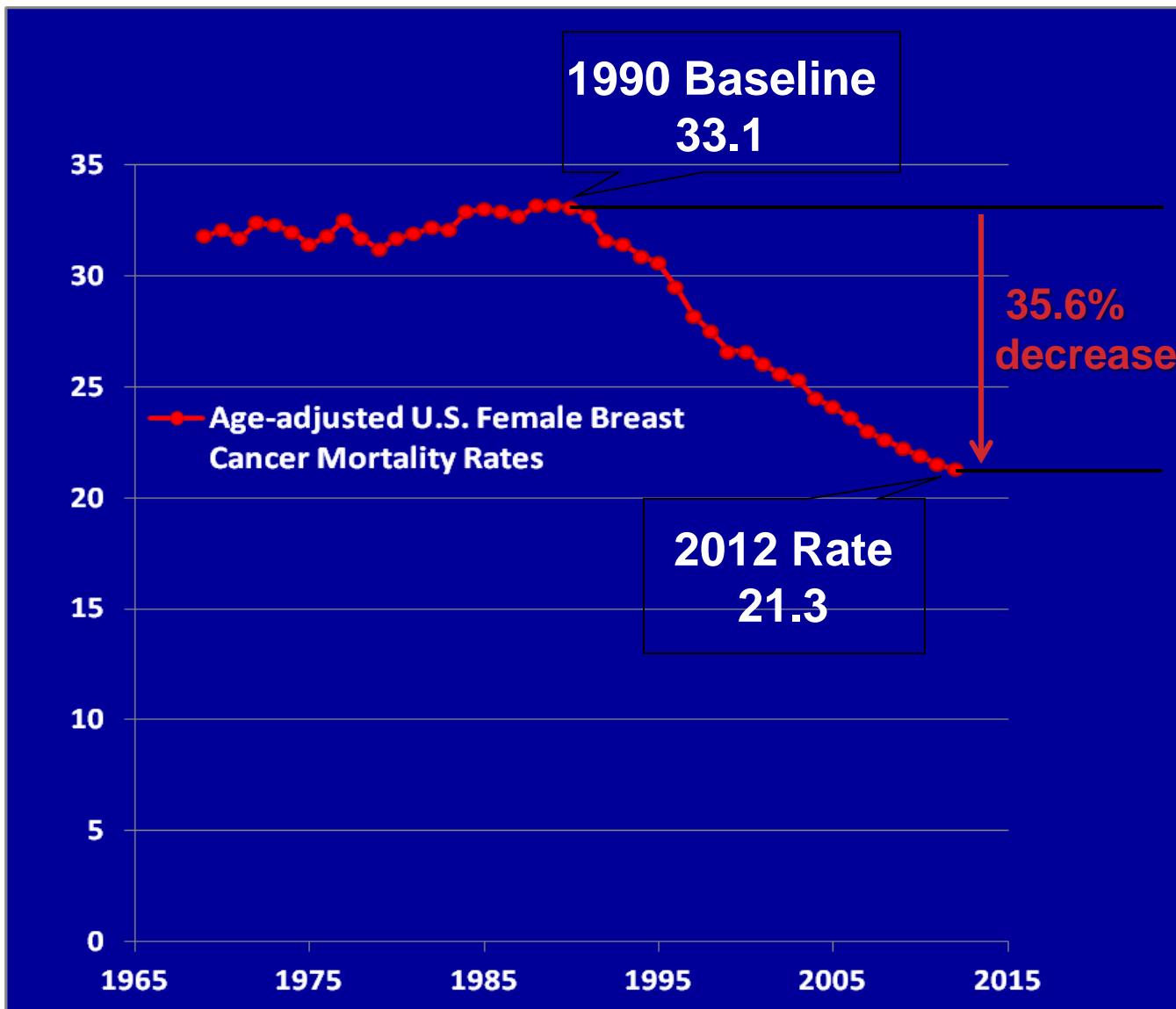
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# Breast Cancer Death Rate 1969-2003



Surveillance, Epidemiology, and End Results (SEER) Program  
([www.seer.cancer.gov](http://www.seer.cancer.gov)) SEER\*Stat Database: Mortality - All COD, Public-Use With State, Total U.S. (1969-2003), National Cancer Institute, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 2006. Underlying mortality data provided by NCHS ([www.cdc.gov/nchs](http://www.cdc.gov/nchs))

# U.S. Female Breast Cancer Mortality Rates 1969-2012, SEER

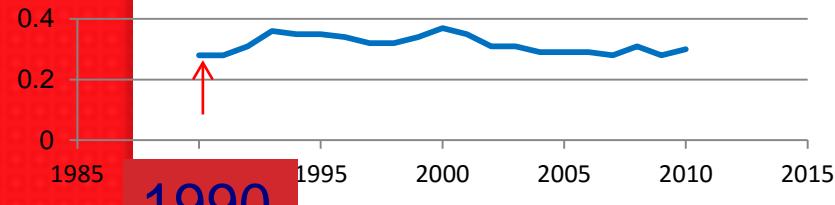


Breast cancer mortality rates per 100,000 women age-adjusted to 2000 U.S. standard population, SEER  
Cancer Statistics Review 1969-2012, slide created by R. E. Hendrick from SEER\*Stat data, released April 2015

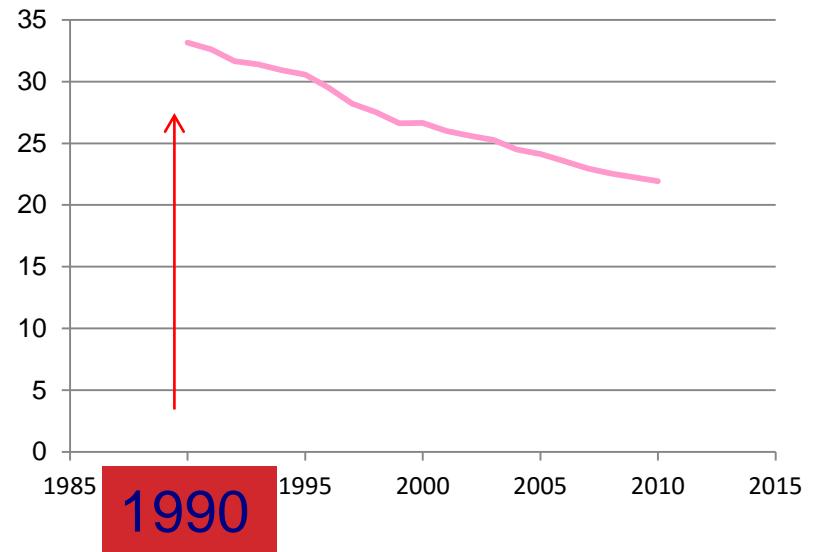
# Technology: future

- Development of national database in the United States to increase screening, track who is screened and follow-up outcomes

### DEATH RATE PER 100,000 MALES

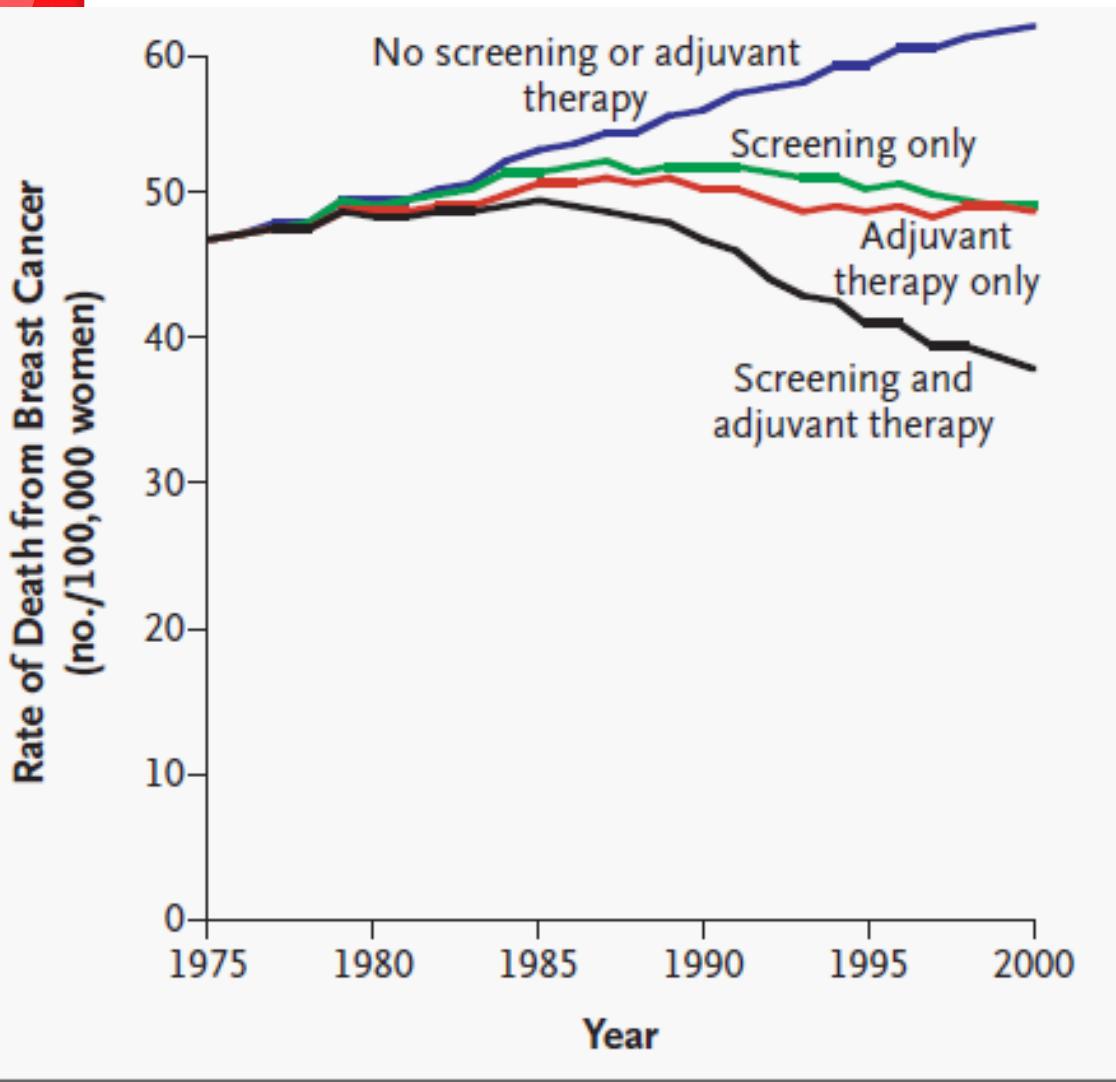


### DEATH RATE PER 100,000 FEMALES



United States: Males vs. Female Breast Cancer Death Rates, 1990-2010

What is the difference between these two groups?



from breast cancer in the United States, and some were not. Panel B shows the results from model W (the University of Wisconsin–Madison) of estimated mortality trends for the four scenarios considered: no screening and no adjuvant treatment; base-case screening, but no adjuvant treatment; no screening, but base-case adjuvant treatment; base-case screening and adjuvant treatment. Rates in both panels are age-adjusted to the 2000 U.S. standard.

## Context: medical & scientific societies

- ACS, AMA, ACR Recommendations
  - Annual screening mammography starting @ 40 for as long as women are in good health

# ACS & USPSTF agree: The most lives are saved with annual screening starting at 40

## American Cancer Society recommendations for early breast cancer detection in women without breast symptoms

Women age 40 and older should have a mammogram every year and should continue to do so for as long as they are in good health.

- Current evidence supporting mammograms is even stronger than in the past. In particular, recent evidence has confirmed that mammograms offer substantial benefit for women in their 40s. Women can feel confident about the benefit associated with regular mammograms for finding cancer early. However, mammograms also have limitations. A mammogram can miss some cancers, and it may lead to follow up of findings that are not cancer.

## USPSTF Assessment

The USPSTF has reached the following conclusions:

For biennial screening mammography in women aged 40 to 49 years, there is moderate certainty that the net benefit is small. Although the USPSTF recognizes that the benefit of screening seems equivalent for women aged 40 to 49 years and 50 to 59 years, the incidence of breast cancer and the consequences differ. The USPSTF emphasizes the adverse consequences for most women—who will not develop breast cancer—and therefore use the number needed to screen to save 1 life as its metric. By this metric, the USPSTF concludes that there is moderate evidence that the net benefit is small for women aged 40 to 49 years.

- “Current evidence supporting mammograms is even stronger than in the past. In particular, recent evidence has confirmed that mammograms offer substantial benefit for women in their 40s”
- “Although the USPSTF recognizes that the benefit of screening seems equivalent for women aged 40 to 49 years and 50 to 59 years...”

# USPST F: 2009

 U.S. Preventive Services  
TASK FORCE

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You are here: Home » Recommendations for Primary Care Practice » Published Recommen

## Breast Cancer: Screening

Release Date: November 2009

 This topic is in the process of being updated. Please go to the [Update in Progress](#) section available.

### Recommendation Summary

#### Summary of Recommendations

Population	Recommendation	Grade (What's This?)
Women, Age 50-74 Years	The USPSTF recommends biennial screening mammography for women 50-74 years.	<b>B</b>
Women, Before the Age of 50 Years	The decision to start regular, biennial screening mammography before the age of 50 years should be an individual one and take patient context into account, including the patient's values regarding specific benefits and harms.	<b>C</b>
Women, 75 Years and Older	<p>The USPSTF concludes that the current evidence is insufficient to assess the benefits and harms of screening mammography in women 75 years and older.</p> <p>Go to the <a href="#">Clinical Considerations</a> section for information on risk assessment and suggestions for practice regarding the I statement.</p>	<b>I</b>
All Women	The USPSTF recommends against <i>teaching</i> breast self-examination (BSE).	<b>D</b>
Women, 40 Years and Older	<p>The USPSTF concludes that the current evidence is insufficient to assess the additional benefits and harms of clinical breast examination (CBE) beyond screening mammography in women 40 years or older.</p> <p>Go to the <a href="#">Clinical Considerations</a> section for information on risk assessment and suggestions for practice regarding the I statement.</p>	<b>I</b>
All Women	<p>The USPSTF concludes that the current evidence is insufficient to assess the additional benefits and harms of either digital mammography or magnetic resonance imaging (MRI) instead of film mammography as screening modalities for breast cancer.</p> <p>Go to the <a href="#">Clinical Considerations</a> section for information on risk assessment and suggestions for practice regarding the I statement.</p>	<b>I</b>

ACS

- 50-74: biennial (Grade B)
- <50 & >75: not routinely (Grade C)

USPSTF

**Different recommendations**

# Why different recommendations?

- Either these “expert” panels have
  - Incomplete understanding of data; or
  - Other motives in deciding their guidelines (\$)

# USPSTF 2015 (draft)

- 50-74: Grade B - biennial
- <50 & >75: Grade C
  - “a "C" grade is a recommendation against *routine* screening of women aged 40 to 49 years”

# USPSTF 2015: The real harms if adopted

- ACA: private insurers must cover tests with B grade or higher
  - 50-74: biennial (Grade B)
  - <50 & >75: no routinely (Grade C)
- Women who want annual screening starting @ 40 may not have coverage

# Individual & Technology

- 44 year-old female feels a lump in her breast
  - Diagnostic mammography & US
  - US-guided biopsy
  - Pathology & molecular analysis
  - MRI for EOD
  - CT or PET/CT to exclude mets
- Q: What future technologies could improve this process?

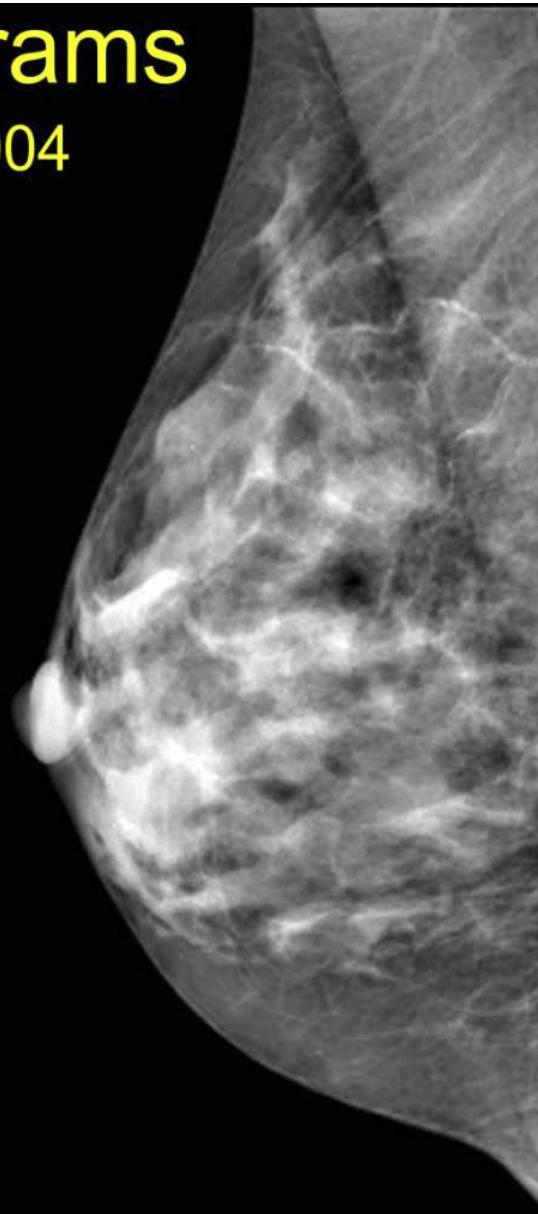
# Technology: Improvement over time

## Mammograms

Circa 1980

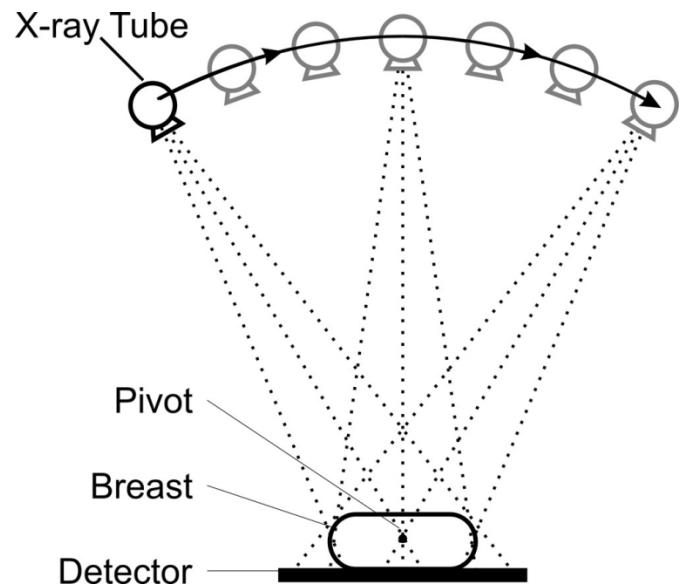


2004



Images courtesy of Dr. Martin Yaffe and Dr. Daniel Kopans

# Technology: 2011 -“3D” mammography (Tomosynthesis)



# Context: Radiation exposure

- 2D
- 2D + 3D
- Background radiation (USA)
- Background radiation (Colorado)
- 0.5 mSv
- 1.0 mSv
- 3 mSv
- 4 mSv

➤ *B/I combo 2D + 3D exam is same as difference in living in NYC vs. Colorado for a year*

# Technology: Future - tomo

- Can standard 2D Mmg be eliminated
  - Potential for “synthetic” mmg
- CAD for tomo
- Opportunity for reduced compression
  - Just to stop motion, as less need for spreading out structures
- Contrast-enhanced tomo

# Individual & Technology

- Diagnostic mammography
- Ultrasound:
  - characteristics diagnostic of malignancy?
- Molecular analysis
  - characteristics diagnostic of malignancy?

# Context / Society & Technology

- National screening program
- Improved screening utilization
- Computer models
- Data analysis

# Conclusion / Objective

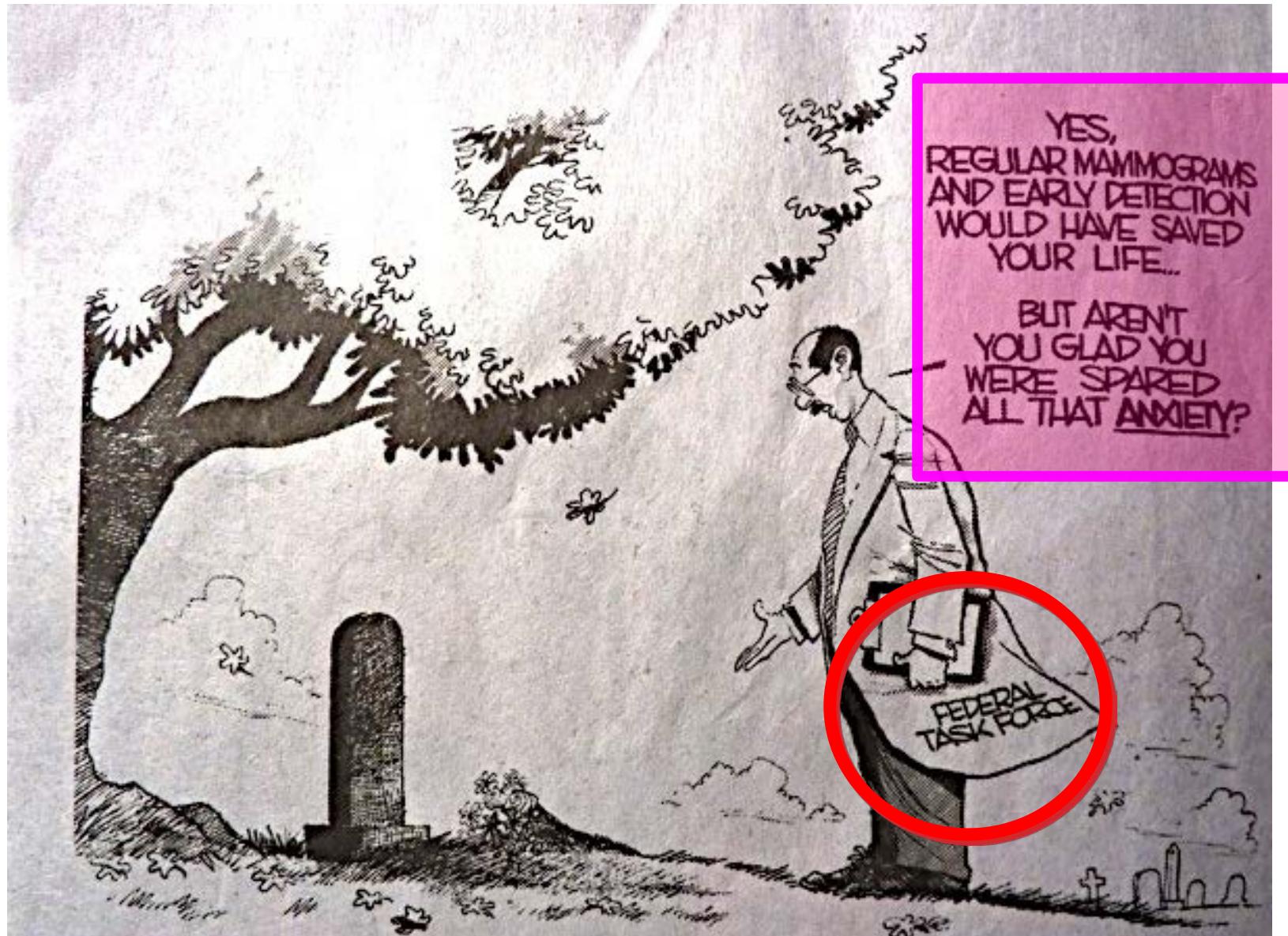
- By the end of the session, the learner (you) should be able to
  - Understand how imaging can screen and help diagnose breast and gyn malignancies
  - Consider how future technologies that might assist in this and understanding these diseases at a population based-level
  - State recommendations for screening behind it and basic supporting evidence

# Glossary

- ACA: Affordable Care Act
- Adjuvant therapy: applied AFTER initial treatment (surgery)
- ACR: American College of Radiology
- ACS: American Cancer Society
- AMA: American Medical Association
- BRCA=One of two genes (**BRCA1** and BRCA2) that help repair damage to DNA, but when inherited in a defective state increases the risk of breast and ovarian cancer.
- DIEP flap: autologous breast reconstruction surgical technique idolizing the deep inferior epigastric perforator vessels
- Elastography: medical imaging modality that maps the elastic properties of soft tissue to help determine whether the tissue is hard or soft
- Endometrium: inner layer/lining of the uterus shed each month during menstruation
- Mammogram: x-ray picture of the breast
  - screening: asymptomatic, no personal history of breast cancer
  - diagnostic: symptomatic OR personal history of breast cancer
- mSv: milli-Sivert, a unit of measuring radiation

# Glossary (continued)

- NCI: National Cancer Institute
- Neoadjuvant therapy applied BEFORE the main treatment (e.g., neoadjuvant chemotherapy to tumor size preop)
- Positron emission tomography (PET)–computed tomography
- RCT: randomized control trial, a study design that randomly assigns subjects into an experimental or control group so that as the study is conducted, the only expected difference between the groups is the outcome being studied
- SEER: Surveillance, Epidemiology, and End Results (SEER) Program, part of the NCI
- Service screening: centrally-organized, large scale screening program with standardized screening procedures and centralized data base with outcomes
- Spectroscopy: with MRI, measures chemical content of breast lesions
- Stereotactic biopsy: biopsy of (typically) calcifications in the breast using mammographic guidance
- Tomosynthesis: 3D mammography
- TRAM flap: autologous breast reconstruction surgical technique idolizing the transverse rectus abdominus muscles
- USPSTF: United States Preventive Services Task Force



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