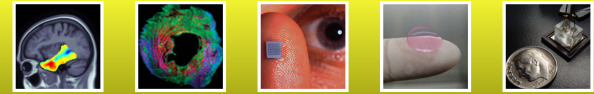
NATIONAL INSTITUTE OF BIOMEDICAL IMAGING AND BIOENGINEERING



Mammography

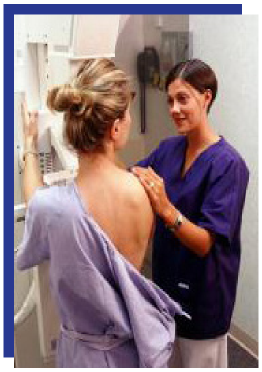
National Institutes of Health

What is a mammagrom?

Mammography is an x-ray imaging method used to examine the breast for the early detection of cancer and other breast diseases. It is used as both a diagnostic and screening tool.

How does it work?

During a mammogram, a patient's breast is placed on a flat support plate and compressed with a parallel plate called a paddle. An x-ray machine produces a small burst of x-rays that pass through the breast to a detector located on the opposite side. The detector can be either a photographic film plate, which captures the x-ray image on film, or a solid-state detector, which transmits electronic signals to a computer to form a digital image. The images produced are called mammograms. On a film mammogram, areas of low density, such as fatty tissue, appear translucent (i.e. similar to the black background)., whereas areas of dense tissue, such as connective and glandular tissue or tumors, appear whiter on a black background. In a standard mammogram, both a top and a side view are taken of each breast, although extra views may be taken if the physician is concerned about a particular area of the breast.



Source: Getty Images

What will the results look like?

A radiologist will carefully examine a mammogram to search for areas or types of tissue that look different from normal tissue. These areas could represent many different types of abnormalities, including cancerous tumors, non-cancerous masses called benign tumors, fibroadenomas, or complex cysts. Radiologists look at the size, shape, and contrast of a mass, as well as the edges or margins, which can indicate the possibility of malignancy (i.e. cancer). They also look for tiny bits of calcium, called microcalcifications, which show up as very bright specks on a mammogram. While usually benign, microcalcifications may occasionally indicate the presence of a specific type of cancer. If a mammogram is abnormal, the radiologist may order additional mammogram views, as well as additional magnification or compression, and if suspicious areas are detected, he/she may order a biopsy.

Why does the breast need to be compressed?

Compression holds the breast in place to minimize blurring of the x-ray image that can be caused by patient motion. Also, compression evens out the shape of the breast so that the x-rays can travel through a shorter path to reach the detector. This reduces the radiation dose and improves the quality of the x-ray image. Finally, compression allows all the tissues to be visualized in a single plane so that small abnormalities are less likely to be obscured by overlying breast tissue.

What is digital mammography?

A digital mammogram uses the same x-ray technology as conventional mammograms, but instead of using film, solid-state detectors are used. These detectors convert the x-rays that pass through them into electronic signals that are sent to a computer. The computer then converts these electronic signals into images that can be displayed on a monitor and also stored for later use. Several advantages of using digital mammography over film mammography include: the ability to manipulate the image contrast for better clarity, the ability to use computer-aided diagnosis, and the ability to easily transmit digital files to other experts for a second opinion. In addition, digital mammograms may decrease the need for the re-takes, which are common with film mammography due to incorrect exposure techniques or problems with film development. As a result, digital mammography can lead to lower effective patient x-ray exposures.

In 2005, results from a large clinical trial sponsored by the National Cancer Institute found that digital mammography was superior to film mammography for the following populations[1]

- Women under 50
- Women with dense breasts
- Women who have not gone through menopause or who have been in menopause less than one year

What are the limits of mammography?

For certain types of breasts, mammograms can be difficult to interpret. This is because there is a wide variation in breast tissue density among women. Denser breasts are more difficult to image, and more difficult to diagnose. For this and other reasons, the sensitivity of mammography in detecting cancer can vary over a wide range. For many difficult cases, x-ray mammography alone may not be sufficiently sensitive or accurate in detecting cancer, so additional imaging technologies, such as ultrasound or magnetic resonance imaging (MRI) may also be used to increase the sensitivity of the exam. Finally, although the majority of abnormal mammograms are false-positives, when cancer is present, early detection can save lives.

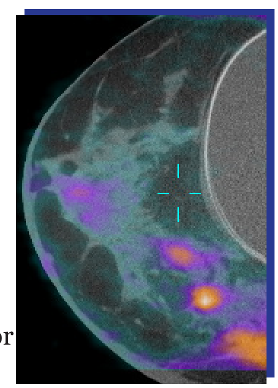
Are there risks?

Because mammography uses x-rays to produce images of the breast, patients are exposed to a small amount of ionizing radiation. The risk associated with this dose appears to be greater among younger women (under age 40). However, in some cases, the benefits of using mammography to detect breast cancer under age 40 may outweigh the risks of radiation exposure. For example, a mammogram may reveal that a suspicious mass is benign and, therefore, doesn't need to be treated. Additionally, if a tumor is malignant and is caught early by mammogram, a surgeon may be able to remove it before it spreads and requires more aggressive treatment such as chemotherapy.Different groups provide different guidelines for mammography. For instance, the American Cancer Society as well as the American College of Radiology recommend that women between the ages of 40 and 49 get mammograms every two years. However, The U.S. Preventive Services Task Force recommends mammograms only for women over age 50. The Task Force states that the benefits of mammography before age 50 do not outweigh the risks. [2,3]

What are examples of NIBIB-funded projects in breast cancer screening?

Tomosynthesis: Digital Breast Tomosynthesis is an FDA-approved method for breast cancer screening in which x-rays of the breast are taken at different angles to generate thin cross-sections. Computer software is then used to reconstruct these images into a 3D representation of the breast, similar to CT technology. Tomosynthesis differs from CT technology in that significantly fewer image slices are taken as compared to CT, in order to keep the radiation dose in line with 2D mammography. While tomosynthesis uses very low-dose x-rays, it is currently used in addition to 2D mammography, making the total radiation dose higher than standard mammography. A recent study found that digital breast tomosynthesis cut false-positive recall rates by 40%.

Dedicated Breast CT: Research funded by NIBIB has led to the development of a dedicated breast CT scanner (dbCT) that allows radiologists to view the breast in three dimensions and has the potential to reveal small tumors obscured behind dense breast tissue. The scanner uses a radiation dose comparable to mammography by sending X-rays only through the breast and not the chest. At present, more than 600 women have been imaged using dbCT in clinical trials. Results from these trials suggest that dbCT is significantly better at detecting tumors than mammography, though mammography is better at detecting microcalcifications. Recently, positron emission tomography (PET) technology has been incorporated into the dbCT platform. A PET scan highlights areas of increased metabolic activity, which could indicate the presence of a tumor. Additionally, injection of a contrast agent has been shown to improve dbCT's ability to detect microcalcifications and could help radiologists distinguish benign from malignant tumors. Research is currently focused on ways in which dbCT could be used to provide real-time image guidance for biopsy needle placement and minimally invasive ablation of tumors. For more information on the dbCT click here.



Breast image generated with dedicated breast PET/CT. Orange and purple represent areas of increased metabolic activity which indicate the presence of a tumor. Source: John Boone, Ph.D., UC Davis

Near-Infrared, Diffuse Light Imaging with Ultrasonic Guidance: Researchers funded by NIBIB have developed a novel hybrid ultrasound/optical breast imaging system that uses simultaneous optical (infrared) and ultrasound sensors in a hand-held probe. The method provides accurate detection of tumor angiogenesis (i.e. formation of new blood vessels) and the distribution of these new blood vessels, which can help distinguish benign lesions from early-stage cancers. The method is being tested in a large number of patients who will also receive ultrasound-guided biopsy. Early results indicate that this may be a promising adjunct to mammography and may help to reduce the number of benign breast biopsies compared to methods that have been in use over the past 20 years. It may also be useful in evaluating the effectiveness of chemotherapy treatments.

1. Digital vs. Film Mammography in the Digital Mammographic Imaging Screening Trial (DMIST): Questions and Answers, National Cancer Institute. Updated Sept 16, 2005. Accessed May 15, 2013.http://www.cancer.gov/newscenter/qa/2005/dmistqandA
2. Mammogram guidelines: What are they?--mayoclinic.com/health/mammogram-guidelines/AN02052, updated May 3, 2013.
3. American College of Radiology-, ACR Practice Guideline for the Performance of Screening and Diagnostic Mammography (acr.org/~/media)-2008 (resolution 24).

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