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Mammography: Still the Imaging Standard

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Breast carcinoma is the leading cause of cancer death in women in the United States. Recent technological advances have resulted in multiple imaging methods designed to improve the detection of breast cancer. These imaging methods are discussed. Mammography remains the most accurate imaging method used to evaluate the breast. Automated water-path whole-breast ultrasound is the most useful adjunctive examination to mammography at the present time.

Breast carcinoma is the most common malignancy in women and the leading cause of cancer death. The estimated risk of development during a lifetime is one in ten for white women and one in 14 for black women in the United States (1). Because of concern over these alarming statistics, multiple imaging methods were developed to improve detection of breast cancer. Currently X-ray mammography is the only imaging method that has the proven ability to detect clinically occult, nonpalpable, early stage breast cancers. Despite the preeminence of mammography in screening asymptomatic women and diagnosing suspected disease, the other available imaging methods serve as important adjuncts in diagnosis. This paper will focus on the efficient use of the various imaging methods for detecting breast carcinoma.

Mammography

Currently film-screen and xeromammography are the two methods employed in X-ray mammography. In both methods, X rays pass through the breast but form the image upon different types of receptors. Film-screen mammography is performed with a dedicated mammographic unit that generates molybdenum or tungsten spectrum radiation. The X rays pass through the breast to expose double emulsion X-ray film held in contact with a single intensifying screen (fluorescent sheet) that glows when hit with X rays. The film-screen system is a high-contrast/high-resolution system, ideal for demonstrating calcifications and soft tissue densities of the breast. This system also has the advantages of short exposure times and low radiation dose to the glandular tissue of the breast. Automated processing is used, and the mammogram is viewed with transmitted light.

In contrast, xeromammography is a variation of the Xerox copying technique. Rather than using film, the X rays impinge upon a semiconductor surface, formed by a selenium-coated aluminum plate, to create a charge pattern corresponding to the image. A charge is applied to a blue powder that is then blown onto the already charged selenium plate. Like charges repel, so the resultant image transfers to a specially treated paper, is fused, and the final image (mammogram) is made. The xeromammogram is viewed with reflected light. This system has a wide latitude of exposure

 although the critical exposure range is within 2 to 4 kV. Image detail is usually quite good with tissue interfaces being well defined due to the “edge enhancement” feature of this technique. Microcalcifications, therefore, are usually clearly visible in the soft tissues of breast; such calcifications are frequently the only sign of early breast cancer.

The standard examination in both types of mammography consists of two views at approximately right angles. For these images, the breast is compressed so that its normal conical shape is transformed into a more rectangular shape. In the craniocaudal view the X-ray beam passes from superior to inferior, and in the oblique lateral view the X-ray beam passes medial to lateral and includes the axillary tail of the breast. Good compression is essential to excellent mammographic technique since it provides for separation of breast structures and uniform tissue thickness, decreases scatter and dose, and improves the overall image quality.

One must consider the radiation dose to the breast from mammography. At Henry Ford Hospital, the mean midbreast dose for a two-view film-screen examination is approximately 0.02 rad per view. For xeromammography, which is not performed here now, the mean midbreast dose has been calculated to be approximately 0.40 rad (2). The dose has been decreased approximately by half by using the negative mode rather than the positive mode for xeromammography. When we performed xeromammography, the dose was 0.4 to 0.6 rad using the positive mode. The potential risk from such small doses is difficult to quantify precisely. According to Feig (3), mammography with a mean glandular dose of 0.1 rad may result in one excess breast cancer death/6 x 10^6 exposed women/year, after a ten-year latent period.

The mammographic features of breast cancer are classically divided into primary and secondary signs. The primary signs...
include a mass with ill-defined margins or peripheral spiculations (Fig 1), often associated with clustered tiny calcifications (Fig 2). Secondary signs that may be present include skin thickening or retraction, fibrous tissue proliferation, nipple retraction, venous engorgement, and axillary lymphadenopathy. Subtle findings that are suggestive of an occult early carcinoma are a circumscribed cluster of microcalcifications (less than 0.5 mm), dilatation of a single retroareolar duct, a localized distortion of breast architecture, and asymmetry with the contralateral breast. Mammography is the only imaging method able to detect microcalcifications.

Using these features, the accuracy of mammography has been established in detecting minimal breast carcinoma of 1 cm or less diameter as well as carcinoma in situ. In the nationwide Breast Cancer Detection Demonstration Project, in which the results of breast-cancer screening in approximately 275,000 women between 1973 and 1980 were examined, 41.6% of the cancers were detected solely by mammography. Approximately one third (32%) of the BCDDP cancers were noninvasive or less than 1 cm in size; 59% of these early cancers were found by mammography alone (4). The true positive rate for cancers found by mammography is reported at 89% from this study, with a false negative rate of 8% to 9%. Our own true positive rate was approximately 75% for the year 1982.

Although mammography is quite sensitive, it cannot detect all cancers. Small nonclassified lesions in a radiographically dense breast, ie, a breast that contains a large amount of fibrous and glandular tissue, can be mammographically occult. In addition, with small masses there is considerable overlap in the appearance of benign and malignant lesions. Nevertheless, the data available clearly indicate that mammography is the most accurate method for detecting early cancers and, therefore, is the standard by which other imaging techniques are to be judged.

Ultrasound

At the present time, ultrasonography is the most useful of the adjunctive breast imaging techniques, when used in combination with X-ray mammography. High-frequency sound
waves are pulsed into the breast tissue from an electronically stimulated crystal within a transducer. The sound waves are reflected from interfaces in the breast back to the transducer, then electronically converted to an image for display. The breast can be examined using hand-held transducers to evaluate palpable masses, or automated water-path whole-breast sonography, which displays the breast in multiple, thin sections. That sonography does not depend upon ionizing radiation is a potential advantage over mammography.

The primary advantage of sonography compared with mammography lies in its improved ability to identify and define any lesions in a radiographically dense breast, particularly cystic lesions (Fig 3). In the fatty replaced radiolucent breast, mammography is clearly superior, however. Sonography readily distinguishes between solid and cystic masses, both of which appear as dense masses by mammography. For simple benign cyst identification, sonography is more accurate than mammography. In differentiating benign and malignant solid masses, sonography is more limited and must rely on the secondary signs of malignancy. Despite the development of diagnostic criteria for the ultrasonic appearance of breast carcinoma, there is overlap with both the appearance of benign breast lesions and normal breast tissue. In addition, sonography is unable to detect microcalcifications and is poorly able to detect small regions of altered architecture that may be the only indicators of an early breast cancer. To date, no data establish breast sonography as superior to mammography in detecting clinically occult breast cancer.

A recent study by Egan et al (5) clarified the complementary role of breast sonography to mammography and physical examination. Sonography following mammography is particularly useful in evaluating dense breasts, in distinguishing whether an ill-defined mass is cystic or solid, in examining areas poorly demonstrated by mammography, and in examining breasts containing a prosthesis. In addition, sonography is of value in young patients, particularly those under 30 years of age, and in pregnant patients.

Computed Tomography

Computed tomography of the breast uses ionizing radiation but must be considered separately from X-ray mammography. The first evaluations of the breast by CT used special prototype scanners that examined only the breast, but these were uneconomical, and standard body scanners are adequate. Chang (6) found a high degree of accuracy in diagnosing breast carcinoma when CT of the breast was performed both with and without the use of iodinated contrast material injected intravenously. The use of contrast material adds risk to the examination. Furthermore, this method of breast imaging is quite costly and involves significantly greater radiation doses to the breast and to the rest of the thorax. Consequently, the ultimate role of breast CT remains uncertain.

Transillumination (Diaphanography)

The recently renewed interest in evaluating the breasts with transmitted light stems from the addition of new technology. The breast is conceived as an optical filter that normally transmits light. Both benign and malignant masses will absorb light, but breast cancer is thought to absorb near infrared light preferentially. The transillumination examination uses a hand-held light source that, when applied to the undersurface of the breast, flashes visible red and near infrared light through the breast to be viewed by an infrared-sensitive television camera linked to a video recorder. Computerized image manipulation can be performed to enhance differences in transmission of the two types of light. The present consensus is that transillumination of the breast is highly operator dependent and is thus inferior to state-of-the-art mammography in detecting breast cancer (7). This is especially true for the small cancers located deep within the breast. Transillumination does provide complementary information in the evaluation of a radiographically dense breast in the same manner as ultrasonography (8). Until consistent diagnostic criteria are developed, and blinded comparisons with mammography of both symptomatic and asymptomatic women are performed, breast transillumination should be considered experimental.
Mammography

Fig 3
Craniocaudal view (A) and mediolateral oblique view (B) of right breast show 2-cm rounded mass in retroareolar region. Ultrasound examination (C) shows sonoluent, echo-free mass with through transmission and well-defined posterior wall characteristic of cyst.
Thermography

Thermography is a passive system for measuring skin temperature. Its use in the detection of breast cancer originates from Lawson's observation that the skin overlying a breast malignancy may be 1° to 3°C warmer than the surrounding tissue (9). Unfortunately, many breast cancers are not sufficiently hypermetabolic to generate the heat necessary for detection by thermography. Moreover, small, deeply located lesions will be well insulated by the surrounding breast tissue so that any heat produced may fail to reach the skin surface. No data establish thermography as a useful screening method in detecting occult early breast carcinoma, especially since this procedure has high false negative and false positive rates. Some suggestion has been made that a positive thermogram is an indicator of increased risk for developing cancer, but the risk is no more than the risk of developing breast cancer intrinsic to being female. For now, thermography must continue to be viewed as an experimental method (10).

Digital Subtraction Angiography of the Breast

Digital subtraction angiography of the breast (DSAB) is a new research technique being developed at Henry Ford Hospital for its potential to differentiate benign from malignant breast disease. Twenty-three women have been examined using this technique, and the results compared to findings of surgical biopsy (11). All the women had a mammographically demonstrated lesion, but not all lesions were suspicious for malignancy.

In this examination, a catheter is introduced via an antecubital vein and positioned in the proximal superior vena cava. The patient is then turned prone, and the breast immobilized in a device of our design; the breast is positioned as for an oblique lateral view with the nipple in profile. Images are obtained after the injection of 30 mL diatrizoate meglumine (Renografin 76) at a rate of 25 mL/sec. Once the contrast material is visualized in the breast arteries, multiple exposures are made both in the arterial and venous phases. The maximum number of exposures is 40. In the normal breast, DSAB demonstrates uniform perfusion and homogenous density without prominent vasculature or focal areas of retained contrast material. All cases of proven malignancy demonstrated a blush of localized prolonged retention of contrast material as well as abnormal blood vessels and prominent breast vasculature (Fig 4).

Typically, a malignant breast lesion will demonstrate a rapid rise in accumulation of iodinated contrast material during the arterial perfusion phase, followed by a rapid washout. We recently have developed a method to quantitate the amount of iodinated contrast material within a breast lesion. Measurement of the iodine pharmacokinetics may provide additional information helpful in differentiating benign and malignant lesions. We also have developed Eigenimage filtering, which may be of use in DSAB (12). This technique suppresses an interfering process or anatomical structure, eg, breast soft tissue, while enhancing the desired process, that is, the blush or breast vasculature. The technique results in the Eigenimage, a single composite image that has greater contrast range than the standard DSA image. Using this technique, vascular structures are seen in a composite image rather than in the multiple images necessary in standard DSA.

Fig 4
Mediolateral oblique view (A) and craniocaudal view (B) of right breast show large spiculated mass in superior inner quadrant of the breast (at 12 o'clock). Frame from DSAB (C) shows tumor blush and prominent feeding vessels considered characteristic of carcinoma.
Mammography

The value of DSAB lies in its potential ability to identify suspicious mammographic lesions as malignant or benign without biopsy. Thus far, all proven malignancies examined have shown signs of malignancy by DSAB. Research in this imaging method is ongoing.

Discussion

The American Cancer Society, American College of Radiology, American Academy of Family Practitioners, and the American Medical Association have recently advocated annual mammographic screening for breast cancer in women over 40 years of age (13). As the number of mammograms increases, so will the number of mammographically suspicious lesions. Sonography is useful in distinguishing cystic from solid lesions, especially in mammographically dense breasts. At present, differentiation of benign from malignant solid lesions cannot be performed satisfactorily without surgical intervention. Surgical biopsy, currently the most accurate method of differentiating benign from malignant breast disease, has its risks and drawbacks. Surgical biopsy is often disfiguring and poses the risk of infection; in addition, the procedure is often quite costly, especially when performed on inpatients.

In the future, DSAB may be an alternative to surgical biopsy. DSAB combines attractive features of CT and angiography of the breast, a relatively short (one hour) procedure time, and a radiation dose less than 2 rad. Since DSAB is performed in women in whom the lesions may prove to be carcinomas, we believe that the risks of the procedure are acceptable. With further development of the pharmacokinetics and Eigenimaging techniques of DSAB, radiation dosage may be subsequently reduced. If this DSAB procedure proves to have an appropriate sensitivity and specificity for differentiation of benign and malignant disease in a large clinical trial, it may prove to be a noninvasive, inexpensive, and accurate alternative to surgical biopsy. Until that time, however, X-ray mammography remains the standard of imaging in evaluation of the breast.

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References