The Rationale and Efficacy of Applying Multiple Imaging Techniques for Breast Examination: X-Ray Mammography and Ultrasound Visualization

Elizabeth Kelly-Fry

Department of Radiology, Indiana University School of Medicine
Life Sciences Research Division, Indianapolis Center for Advanced Research, Inc.
926 West Michigan Street, Room A-32, Indianapolis, Indiana 46223

Abstract

Since failure to biopsy a malignant mass during a relatively early stage of its development will result in a severely shortened life span for the patient, breast imaging techniques must be capable not only of detecting a mass, but of differentiating between the image characteristics of a benign and a malignant tumor. Ideally, the applied technique should be equally capable when used to examine the young breast and the older breast. The specific advantages and disadvantages of x-ray mammography and of ultrasound visualization, as well as the rationale of balancing the disadvantages of one technique with the advantages of the other, are discussed in this presentation.

Introduction

The endpoint of most current breast examinations is to determine whether there is an isolated, discrete mass within the breast which has imaging characteristics that differ from the immediately surrounding tissue and, on the basis of these characteristics, to make a judgement whether or not surgical biopsy should be carried out to confirm the possible malignant nature of the mass. Statistically, most masses found in the breast are of a benign nature. Further, the common existence of such benign masses in both the young and the older breast and, in some cases, the recurring nature of such masses, precludes a recommendation that all discrete breast masses should be surgically biopsied. However, failure to biopsy a malignant mass during the stage of its development when malignant cells have not yet migrated to the lymph nodes will result in a severely shortened life span for the patient. Consequently, breast imaging techniques must not only be capable of detecting a mass, but also of differentiating between the sometimes subtle differences between imaging characteristics of benign and malignant tumors. Further, the applied techniques must be equally capable of detecting and differentially diagnosing masses in the young and in the older breast. For the most commonly used instrument technique for breast examination, namely, x-ray mammography, this latter requirement cannot be satisfied in all cases since breast tissue components and their architectural distribution change with the aging process to an extent that a mass which is distinctly delineated in images of the older, fatty breast may not be discernible in images of the young dense breast due to relatively small differences in density between the mass and the surrounding tissue components.

X-ray mammography has many advantages for breast examination including the capability of detecting microcalcifications and tissue masses less than 0.5 cm in diameter; however, it cannot meet all of the requirements for detection and accurate differential diagnosis, and such capability should not be expected from this one modality. Rather than applying x-ray mammography as the sole breast imaging instrumentation technique, emphasis should be placed on developing and applying other imaging modalities for those specific cases where x-ray mammography is not diagnostic, or where its ionizing character is inappropriate in terms of a patient's age or other patient parameters. Further, advantage should be taken of the multiple diagnostic information provided by applying x-ray mammography and one or more additional imaging modalities when a firm differential diagnosis cannot be obtained, with certainty, by any of the individual examination techniques. This paper is primarily concerned with the capability of ultrasound visualization for breast examination when applied in conjunction with x-ray mammography and when used as a single examination technique.

Background of the Breast Cancer Problem in the United States

For the past forty years, for women in the United States, death from all causes has been decreasing, with the exception of death related to breast cancer, i.e., although there may be some recent gains, there has been little significant change in death rate for that specific malignant disease. In terms of survival time, some progress has been made but, unfortunately, this is accompanied by an increasing incidence in breast cancer which is of the order of 1% per year. If a malignant tumor is localized to the breast, approximately 85% of the women will survive for five years after diagnosis but, if it has spread to the lymph nodes, then only approximately 55% will survive that first five-year period. Spread of the malignant cells beyond the lymph nodes is an extremely ominous sign, and only 10% of these patients survive that five-year period. However, if malignant tumors can be detected
while they are in the noninvasive stage and/or are less than 5 mm in diameter (so-called "minimal breast cancers"), the life span for the average patient can be close to normal, thereby providing the patient with an opportunity to pursue her active life in the United States. The problem of the diagnosis of breast cancer is an issue of concern among women in the United States, the World Health Organization, and the American Cancer Society. The problem is one of concern among women in the United States, the World Health Organization, and the American Cancer Society.

Apart from questions regarding possible deleterious effects of ionizing radiation, it is reasonable to ask why it is necessary to consider other breast imaging modalities when x-ray mammography is so well established? What advantages does it have over other modalities? Why is it necessary to consider other imaging modalities when x-ray mammography is already so well established? What advantages does it have over other modalities?

In respect to the above question, the most important fact is that the two most common methods of breast examination in the United States are manual palpation and x-ray mammography. Women over 50 years of age are examined for breast cancer every year. Early detection, in association with advances in the treatment of breast cancer, is the key to decreasing the frequency of death rates from breast cancer. It is generally recommended to use x-ray mammography to examine breast cancer, because it is capable of detecting lesions as small as 5 mm in greatest diameter, or does it mean that most of the women who have x-ray mammograms of their breasts are women in the age range associated with high breast cancer incidence? Are patients associated with mortality rates from breast cancer which are significant to the above question, including the possible systemic nature of breast cancer, and the growth rate of the malignant cell? These views will not be considered in this discussion since the influence of such factors are not resolved.

In respect to the above question, the most important fact is that the two most common methods of breast examination in the United States are manual palpation and x-ray mammography. Since over 90% of women who develop breast cancer detect their own malignant masses, it can be assumed that of these two examination techniques, manual palpation is the most commonly used. This does not mean, however, that a large percentage of women use self breast examination. According to a 1977 survey by the American Cancer Society of a selected population indicated that only 24% of women said they practiced self breast examination monthly. Although the proportion of patients doing self breast examination probably has increased since that time, it is nevertheless reasonable to assume that most patient-detected breast masses have been accidentally found because of their large size. If a physician carries out this examination, the smallest tumor will be of the order of 1 cm in size, while if the patient carries out a breast self examination, it has been estimated that the smallest detectable tumor will be of the order of 1.6 cm in size. Clearly, then, one must to the previously raised question in that the most commonly used method to examine the breast, namely, the application of the human hand, is not an effective means for detecting small masses and, therefore, has only limited benefit in terms of the life span of the breast cancer patient.

The second most commonly used technique for examination of the breast, x-ray mammography, is of the utmost importance. For many years the general medical community has been critical of x-ray mammography. The population considered at risk for breast cancer are women over the age of 35; in the United States, there are approximately 5 million in that age range. Based on a 1977 figure, approximately 4% of that population (2 million) receive an x-ray mammography examination. The number of patients associated with the mammogram represents the number of patients being examined by the most widely used instrumentation modality at least partly associated with the diagnosis that exists in the United States. The second most common method of detecting breast cancer is not the purpose of this presentation to analyze the breast x-ray mammogram. In all probability, the problem of breast cancer is relevant to the human population, since if breast masses in symptomatic patients of all ages can be accurately diagnosed, using either a palpation procedure or a mammography modality, then it is possible that a significant benefit can be realized. If breast cancer patients are detected early, it might be possible to avoid some of the diagnostic procedures, such as the use of surgery for breast cancer; however, a clear differentiation should be made between the two methods that rely on the general philosophy of the work of the American Society of Breast Disease and the significant advantage of mammography. The patient is more likely to benefit from mammography, a non-invasive diagnostic accurate technique for detecting breast cancer.

Advantages and Limitations of X-ray Mammography

In terms of an efficient clinical procedure, x-ray mammography allows fast examination of both breasts, and provides two-dimensional images of total breast volume which can be read in perfect detail. Thus, the technique has the capability of detecting a mass less than 5 mm in diameter within the breast and defining regions of interest for further investigation. Breast cancer, which is a frequent cause of death for those subjects who are older than 50 years, is potentially lethal. In addition, it is considered that the risk of death increases with the time of diagnosis. The detection of a mass in such breasts is critically important. 1) Imaging the breast by x-ray mammography to sharply outline malignant masses that are not well defined in other modalities, which often accompany malignant breast disease. There is considerable variation in the mammographic appearance and it is not uncommon for a malignant lesion to be seen in the mammogram.

In determining the benign or malignant character of a breast mass on the basis of its ultrasound image, the primary characteristics evaluated were: (1) whether or not the mass is solid, grossly irregular, or of a fine, abrupt margin; (2) the density and echogenicity of the ultrasound images, and (3) the presence or absence of microcalcifications of the type generally associated with malignant pathology.
of the tumor was well demarcated from the surrounding tissue and whether it exhibited a smooth or jumbled structure: (1) whether the internal echo pattern of the mass was homogeneous, non-homogeneous, or non-visible; and (3) the degree of attenuation shadowing in terms of the shadow and its associated width of the shadow. The volume location of the shadow was not associated with the volume location of the mass. The absence of these phenomena was noted, but particular emphasis was placed on the volume of all of the mass enclosed by the shadow. The volume location of the shadow was noted, that is, whether the entire volume, or only a small portion of the volume, was shadowed, or whether there was no shadow. The absence of this phenomenon was not considered significant since earlier experimental studies indicated that it was unlikely that echographically visible tumors would be sufficiently homogeneous to produce such a shadow. This phenomenon was also noted, but the absence of this phenomenon was not considered significant since earlier experimental studies indicated that it was unlikely that echographically visible tumors would be sufficiently homogeneous to produce such a shadow. If a distorted architectural pattern, as imaged by ultrasound, was noted, the possible presence of a malignant mass was considered, and efforts were increased to obtain other diagnostic information. 

Over a 46-month period, 1892 subjects were examined, and a total of 72 cases of biopsy-proven carcinomas were found in this primarily symptomatic population. A diagnostic accuracy of 95% was obtained for the ultrasound mammography technique. Combined x-ray and ultrasound mammography yielded 100% accuracy. The clinical-research program under which these results were obtained has now been completed.

**Discussion**

For ultrasound imaging systems, the magnitude of an echo is dependent on the magnitude of the difference in acoustic impedance between two interfaces: the larger the difference, the more intense the echo. The characteristic impedance of biological and non-biological materials is dependent on the value of their acoustic velocity and their density. Acoustic velocity is dependent on both density and elasticity of materials but, in the case of biological materials, has a significant association with elasticity, a tissue characteristic which probably has an association with the benign or malignant character of a breast mass. It can be expected that future sophisticated tissue characterization investigations will provide additional diagnostically relevant information on this and other tissue characteristics of breast masses which will further increase diagnostic accuracy. However, present ultrasound instrumentation has sufficient sensitivity to differentiate the small differences in acoustic impedance between various normal breast tissues and between normal and pathologic tissues. This method provides good contrast images of these tissues. The strongest rationale for the use of ultrasound mammography is that, for those specific cases where x-ray mammography cannot clearly delineate the mass from the surrounding normal tissue, ultrasound visualization can provide good contrast images. Common examples are ultrasonically detected benign masses in the very dense breast of a young woman, and benign masses located within similar breast regions of the breasts of older subjects.

The tomographic aspect of ultrasound imaging in respect to evaluating primary imaging characteristics such as wall structure, internal echo pattern, attenuation, and architectural patterns over the full volume of the mass, is particularly significant in regard to diagnosis because it takes into account varying structural features of malignant masses within different regions of the tumor. For those cases where adequate imaging is obtained by both modalities, the confirmation by ultrasound visualization of certain features revealed by mammography, such as wall structure, and the ability of other types of information such as internal echo structure and unique characteristics of attenuation, increases the accuracy of diagnosis. Basic to the accuracy of diagnosis is the proper qualification of both x-ray and ultrasound mammography is the presumption that, for both modalities, only instruments designed for the specific purpose of breast examination will be used.

---

**References**


