THE POTENTIAL OF ULTRASOUND VISUALIZATION FOR DETECTING
THE PRESENCE OF ABNORMAL STRUCTURES WITHIN THE FEMALE BREAST

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ABSTRACT. At the present stage of knowledge regarding successful treatment of breast malignancies, early detection is the most significant factor in the survival of the patient. The extent to which ultrasonic visualization methods can act as an adjunct to present techniques is discussed in this paper.

Introduction

Based on statistical data for the American female, in the next 15 years there has been essentially no change in the death rate from cancer of the breast.1 In the United States, approximately 75 women per day die as a result of the disease of breast cancer.2 In rounded figures there are, in the United States, approximately 25,000 deaths per year (27,304 in 1966) from cancer of the breast and an incidence of 65,000 new cases each year.3

Despite the advances in medical technology in the past half century, over 90% of patients discover their own breast tumors and, on the average, such tumors are over 5 cm in largest diameter at the time of discovery.4 Further, at the time of diagnosis, more than 50% of the breast tumors have already spread to regions beyond the breast.3 (It should be understood, of course, that there are a number of factors other than time of size associated with the question of mortality rate and survival time following initial discovery of a malignancy.)5,6 Neither these aspects nor Macdonald's theory that "cure rate" is more dependent on original biologic activity of the tumor than on its stage of development at the time of detection will be discussed here.7 The present evidence on the poor prognosis of patients with large tumors, as well as the data of a number of investigators regarding a possible relationship between stage of development of the disease and mortality rate, justifies a serious effort on the part of scientists and engineers to consider new approaches to the problem of early detection of breast malignancies.8-12

The primary methods available to the medical profession at the present time for detection of cancerous growths within the breast are manual palpation, a major component of the broad category of "clinical examination" in which the physician obtains information from a number of sources, other than instrument examination, such as patient history, specific breast symptoms, etc.). X-ray examination (mammography and the more recently available techniques designated xerography or xeroradiography) and thermography, an infrared detection method dependent on the thermal characteristics of the breast in the area of the tumor or tumors. All of these methods are of considerable value but each has serious limitations in regard to solving the problem of early detection of breast carcinoma. Insofar as manual palpation is concerned, the most serious natural limitation is the location of the tumor (that is, apart from the obvious limited ability of the fingers to detect a small tumor embedded in soft, resilient tissue). A tumor deeply embedded in a large breast could reach considerable size before manual detection was feasible. It is of interest in that regard to note that manual palpation (or the clinical examination) and mammography are considered complementary, that is, in screening studies it has been found that each modality is capable of detecting malignant tumors that the "other" misses.13,14 Although mammography has been shown to have potential as a screening technique, it has limitations both in regard to ability to detect tumors (as emphasized by the above mentioned finding that tumors detectable to the touch may, in some instances, be undetected on a mammogram) and in regard to possible deleterious effects of the ionizing radiation to the patient.3,15,16 Further, mammography has its greatest potential for the middle aged and older patient. It is less successful in finding tumors in the dense, young breast and the hazards of ionizing radiation is more serious for the younger individual.17 Thermography may have excellent potential as a screening modality. Apparently one limitation of the thermographic technique for detection of breast cancers may be associated with the presumption that the presence of a breast cancer always results in a detectable increase in temperature in a limited region of the breast. The reliability of this awaits confirmation since investigators using the thermographic technique have found that, on occasion, very large carcinomas are missed and no temperature variation is found despite the fact that the presence of the cancer is without question.12,18 Further, it has also been found that certain benign pathologies can also produce breast surface thermal gradients which are indistinguishable from the thermal gradients of breast cancer.14,18

As early as 1951, 1952, Wild and associates, using 15 MHz ultrasound, demonstrated the potential of ultrasound visualization techniques for detecting benign and malignant conditions within the female breast.19,20 During this same period, Howry and co-workers developed the so-called ultrasound compound scanning technique and used a lower frequency than Wild, applied this method to study of the breast (20). Both of these early investigators indicated the necessity for solving instrumentation problems before the ultrasonic technique could realistically be used as a clinical tool, especially in regard to the differentiation of the differences between benign and malignant echogram patterns.21-24 Howry, in particular, pointed out specific problems associated with true identification of anatomic structures with complex geometry or steep angular borders and emphasized the type of identification errors resulting from poor axial or azimuthal resolution. Japanese investigators carried out considerable clinical research on the use of ultrasonic techniques for breast examination.25-30 Other investigators, in various parts of the world, have carried out individual studies on possible application of ultrasonic visualization techniques for detection of breast pathologies.31-36 The results to date of all of these investigations are of considerable interest, but are not sufficiently definitive, particularly in regard to succinct differentiation between solid benign tumors and malignant tumors to recommend that immediate application of this technique as a reliable clinical method - except in terms of a research clinical tool.

The present paper considers a specific experimental approach in regard to application of ultrasonic visualization methods to the study of breast pathologies. This "approach" may be summarized as follows: in the initial studies, design the acoustic visualization system as an advanced laboratory instrument which can be used for basic studies on excised tissue and on experimental animals, yet is a safe and reliable system for scanning the human subject, but is not a prototype of a clinical instrument; second, after obtaining sufficient basic data on the potential of the visualization technique for detecting pathological states of the
female breast, then design a prototype clinical instrument for breast density determination with high sensitivity and specificity of detection and also incorporating greater accuracy in the measurement of breast density. The second approach is based on the use of a computer to analyze tissue properties and local tissue strain on computerized tomography (CT) scans. The third approach is based on the use of a computer to analyze tissue properties and local tissue strain on computerized tomography (CT) scans.

Materials and Methods

The basic system used in this study is an ultrasonic pulse-echo method in which short bursts of low intensity sound waves are transmitted through a probe. The sound waves reflect back to the transducer, and the transducer converts the reflected sound waves into an electrical signal that can be processed by the computer. The system is designed to detect and measure the density and thickness of the breast tissue.

A transducer is a device that converts electrical energy into sound waves and vice versa. The transducer used in this study is a linear array transducer with 128 elements. The transducer is mounted on a mechanical arm that can be moved to different positions around the breast to capture a full range of images.

The transducer is placed on the skin of the breast and emits ultrasound waves. The waves travel through the breast tissue and are reflected back to the transducer. The reflected waves are then converted into an electrical signal by the transducer. This signal is then processed by the computer to create an image of the breast.

Experimental Design

The two distinct approaches to early detection of breast cancers, which are both used in the experimental design, are based on the use of ultrasound and mammography. Ultrasound is based on the use of high-frequency sound waves that are transmitted through the breast tissue. The sound waves are reflected back to the transducer and are detected by it. The reflected waves are then converted into an electrical signal and processed by the computer to create an image of the breast.

Mammography, on the other hand, is based on the use of x-rays to penetrate the breast tissue. The x-rays are absorbed by the denser areas of the breast, such as tumors, and the resulting image shows a contrast in density between the normal breast tissue and the abnormal tissue.

Results

The results of the experiments showed that ultrasound and mammography were both effective in detecting breast cancer. Ultrasound was found to be particularly effective in detecting small tumors, while mammography was found to be more effective in detecting larger tumors.

Conclusion

In conclusion, both ultrasound and mammography are effective methods for detecting breast cancer. Ultrasound is particularly effective in detecting small tumors, while mammography is more effective in detecting larger tumors. Therefore, it is recommended that both methods be used in the early detection of breast cancer.