INVESTIGATIONS OF THE ADVANTAGES OF A MULTIPLE FREQUENCY ULTRASOUND BREAST EXAMINATION INSTRUMENT

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In medical communities in all parts of the world, ultrasound mammography is routinely applied as an adjunct technique to x-ray mammography for women over the age of 30 and as the initial examination for young women.[1] The normally dense breasts of young women can be distinctly imaged by ultrasound but may not be well imaged by x-ray mammography.[1] In those medical facilities where a dedicated ultrasound breast examination instrument is available, ultrasound imaging is used as the initial instrument breast examination of symptomatic pregnant women irrespective of their age category. Its acceptance as an adjunct technique to x-ray mammography is due to its success in providing diagnostic information in cases where: (1) The patient that has a diffusely dense breast, resulting in a non-diagnostic x-ray mammogram; (2) the x-ray mammogram indicates an overt region of dense tissue in an otherwise fatty breast and it is not possible to determined whether a mass is lodged in the dense region and (3) a mass is apparent on the x-ray mammogram, but its imaging characteristics are so vague that the diagnosis is indeterminate and/or it can not be determined whether the mass is solid or cystic.

However, despite the high diagnostic accuracies obtained by some users of the ultrasound visualization method, many physicians remain uncertain as to whether or not they can rely on ultrasound mammography beyond its ability to determine whether a mass is solid or cystic. As can be expected, their greatest uncertainty is often associated with diagnoses which indicate, on the basis of ultrasound imaging, that a solid tumor is benign. As an approach to solution of this problem, in this study, an attempt is made to obtain more detailed image information about the image characteristics of solid masses than that presently provided by standard ultrasound techniques. The additional image data is obtained by application of a research instrument (B-mode, linear scan) which provides for examination of the compressed breast with a single, sharply focused transducer which can be energized to emit either higher (7.0-7.5 MHz) or lower (3.5-4.0 MHz) center frequencies. The ability to obtain both a high and a low peak frequency from a single transducer was documented with a spectrum analyser. Frequency response curves under different conditions of transducer pulsing were correlated with breast scan images obtained under the same set of pulsing regimes.

Previous investigations have shown the importance of sharp focusing, (i.e. narrow beamwidths) to accurate diagnosis of breast masses.[2,3,4] The requirement for a narrow beamwidth is not only associated with its importance to lateral resolution but is specifically significant in terms of decreasing some of the beam defocusing that is normally associated with travel of ultrasound through breast tissue.[3,4] In the studies reported here, a number of transducer designs are being used to provide the required narrow beamwidths. Included are transducers fabricated from the polymer material polyvinylidene fluoride, (PVDF).* In contrast to conventional ceramic piezoelectric materials, this polymer film has an acoustic impedance which is close to tissue and has additional properties that make it a good piezoelectric element.[5,6] Both experimental and theoretical studies have shown that the low acoustic impedance of this material results in less reverberation or ringing of the piezoelectric assembly and thus the transducer can operate with wide band characteristics and transmit short duration acoustic pulses.[5,6] Thus, excellent lateral and range resolution can be achieved. Although the electromechanical coupling factor of PVDF is not as large as that of PZT, sensitivities which are within a few dB of that of PZT have been achieved and transducers with frequencies ranging from 2-20 MHz have manufactured.[5,6] A number of investigators in Japan are using PVDF transducers in their breast examination studies. In that regard, the investigations of Takahara, et al and Kasumi et al are of particular interest.[7,8]

It has been shown in this research that the ability to switch from a low to a high frequency, without interchange of transducers, has advantages for breast examination. Included in these advantages is the capability of scan searching large sized breasts at a low frequency without undue attenuation. If a mass or other abnormality is detected then that region can be quickly scanned at a higher frequency. Alternately, if routine scanning is carried out at a higher frequency, a switch to low frequency can be quickly accomplished for examination of overt regions of high attenuation.[9] Further, low and high frequency comparison images at an exact scanning plane can be accurately obtained since no transducer interchange is involved. Scattering phenomena related to frequency can thus be more readily detected and analysed.[7,8,9]

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Illustrations of the varying image characteristics of solid masses, and, in particular, fibroadenomas, at the different examination frequencies will be included in the presentation. The improved imaging of the internal structure of solid tumors and wall structures, at the higher frequencies will be demonstrated.[10] Specific advantages of lower frequency examination will also be illustrated.

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