The Benefit of Ultrasound Imaging in Evaluation of the Breast: Review of a 3-Year Clinical Program

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DURING THE LAST three years, approximately 1,000 patients have been examined at the Regenstrief Health Center with ultrasound techniques both as the primary examination and combined with low dose film mammography. The patients are predominantly symptomatic. We have found that ultrasound visualization surpasses mammography in accuracy of diagnosis for both cystic and solid lesions in patients with the "dense" breast.[1,2] For the older, predominantly fatty breast, the primary advantage of ultrasound is associated with gaining further information on tumor characteristics, which can be used in conjunction with that provided by x-ray to yield increased diagnostic accuracy.

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Methods and Instrumentation

The ultrasound instrument was developed by the Indianapolis Center for Advanced Research, Inc. (located at the Indiana University Medical Center) by modifying a commercially available instrument to provide features found to be essential for accurate diagnosis of breast pathologies.[1,3] The unit is a simple B-mode linear, automated scanning unit, which provides multiple static images of the breast.

The patient is supine and a water bag technique is used to transmit the sound wave to the breast. Mineral oil is used on the skin to prevent the loss of sound transmission due to formation of air pockets (particularly in the region of the nipple) between the skin and the water bag surface. The transparent water bag allows viewing of the breast during the scan, is counter-weighted, and can be manually lowered to the surface of the breast, angulated to conform to the breast contour and rotated so that the transducer can scan transversely, longitudinally or diagonally.

For each single ultrasound scan, the transducer travels a linear path of 12 cm. Multiple static images are

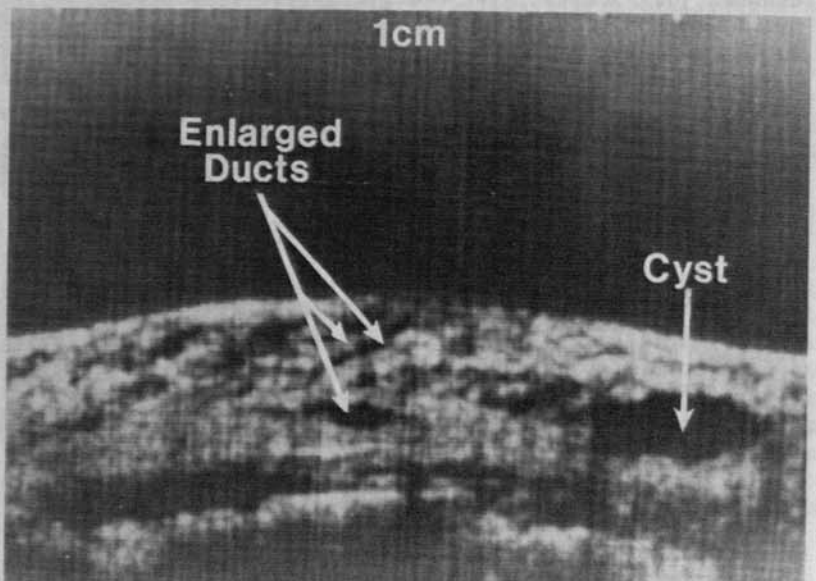

Fig. 1: Ultrasound image of breast of a 35-year-old female with fibrocystic disease, obtained from a transverse scan across the nipple and areola. Enlarged ducts and an overt cyst are clearly evident.

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performed at two chosen space intervals; either 1 mm or 5 mm tissue paths may be selected. In routine scanning of the whole breast, 5 mm step intervals are used, but if any mass or other abnormality is identified, this area is re-scanned at 1 mm step intervals.

The single focus transducers used in this instrument have been specifically designed and fabricated in the research laboratory to yield a range and lateral resolution that is sufficient for diagnosis of small breast masses (i.e., less than 5 mm). In general, a 3.7 MHz transducer is used, but other transducers of lower and higher frequencies can be interchanged as deemed necessary.

The following types of breast pathologies were most commonly encountered in our program:

Fibrocystic Disease. These patients complain of bilateral nodular breasts, with masses of varying sizes occurring at different stages of the menstrual cycle. Some of these patients have had multiple surgical biopsies because low dose film mammography does not adequately delineate these lesions. With our instrumentation, both large and small cystic lesions (i.e., as small as 2 mm in size) have been demonstrated (*Fig. 1*). Further, because scans are easily reproduced and no ionizing radiation is involved, patients with cystic masses have been followed at closer time intervals than normally would be done with film mammography. The possible effectiveness of a low caffeine diet on fibrocystic disease is being investigated in a few subjects.[4]

The Pregnant and Post-Partum State. The pregnant patient with a newly palpable or enlarging mass presents a dilemma to the physician. Malignancies in these patients accelerate in growth in a short time, and, therefore, it is important to differentiate the benign from the malignant mass as early as possible. However, the increase in glandular tissue that occurs in the breast of the pregnant woman decreases the diagnostic accuracy of x-ray mammography. In our studies, such masses are well defined with ultrasound visualization, and a differential diagnosis is easily obtained with use of this technique (*Fig. 2*).

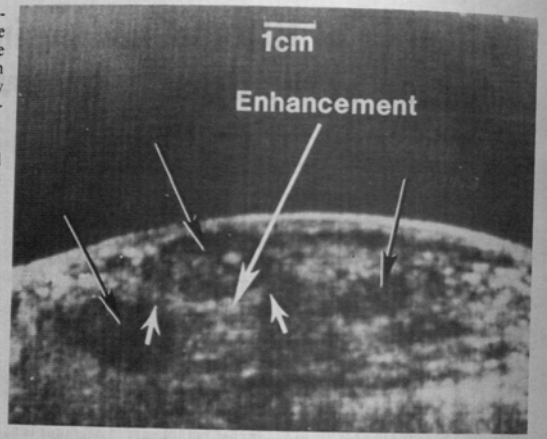


Fig. 2: Ultrasound image obtained from a transverse scan of breast of a young, pregnant patient with multiple fibroadenomas.

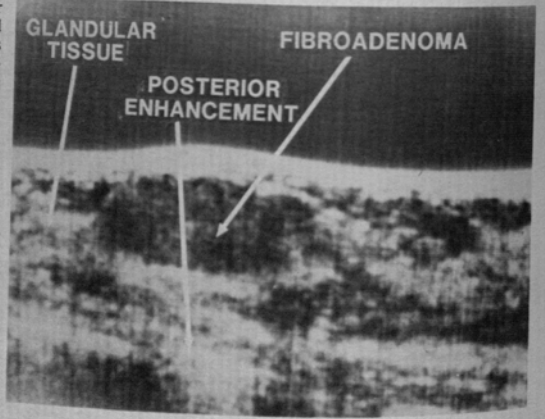


Fig. 3: Ultrasound image of fibroadenoma in breast of a young patient. Note the homogeneous internal echoes of the mass.

Benign Solid Masses. In our population, the most common benign solid mass was the fibroadenoma. These occurred mainly in the 15-year to 35-year age group. With ultrasound, most fibroadenomas have certain characteristics, namely, the walls of the masses are smooth, the internal echoes are relatively homogeneous, and either no attenuation of the beam can be observed visually or it is extremely minor (*Fig. 3*).

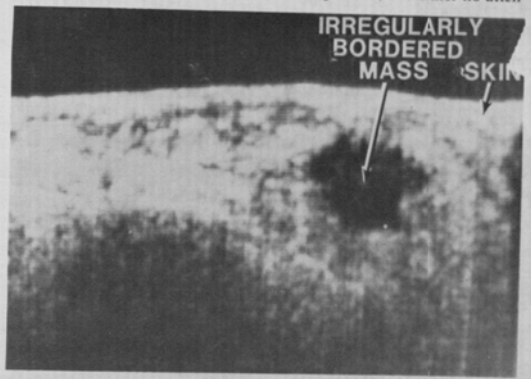
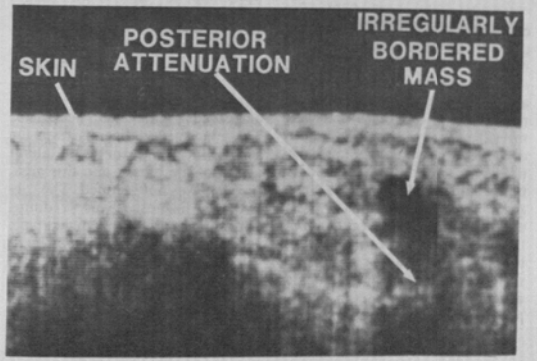


Fig. 4: Ultrasound image of infiltrating duct carcinoma in breast of a 57-year-old patient. Above photo demonstrates marked irregularity of the wall of the mass. Photo below shows the acoustic shadowing posterior to the mass.



Initially, x-ray mammography was performed together with ultrasound for patients of all ages. However, it was found that the x-ray technique was non-diagnostic in the majority of young patients because of the density of the breast; therefore, our current procedure is to use ultrasound as the initial examination for all young patients (i.e., less than age 30) with a palpable mass. X-ray mammography is then used only if the ultrasound examination indicates the possible presence of a malignancy.

Malignant Masses. The age range of patients with pathologically proven carcinoma was between 36 and 70 years. The masses ranged in size from 0.8 to 7.0 cm. The most common type of malignancy was the infiltrating ductal carcinoma. The ultrasound image characteristics of malignant masses most commonly seen were: 1) irregular walls; 2) non-homogeneous internal echoes; and 3) attenuation of the ultrasound beam as indicated by acoustic shadowing *(Fig. 4)*. The extent of these characteristics may vary in different regions of the tumor and, therefore, we have found that it is extremely important to study all mass lesions at 1 mm step intervals in order to evaluate the tumor mass in its entirety *(Fig. 5)*.

Medullary carcinomas may exhibit characteristics that are sometimes difficult to differentiate from benign fibroadenomas. The two cases in our study were, however, correctly diagnosed, as specific attention was paid to slight irregularity of the wall of the mass and the non-homogeneous echo pattern.

Results

The results discussed below reflect the patients who were diagnosed as having either benign or malignant pathology for the period

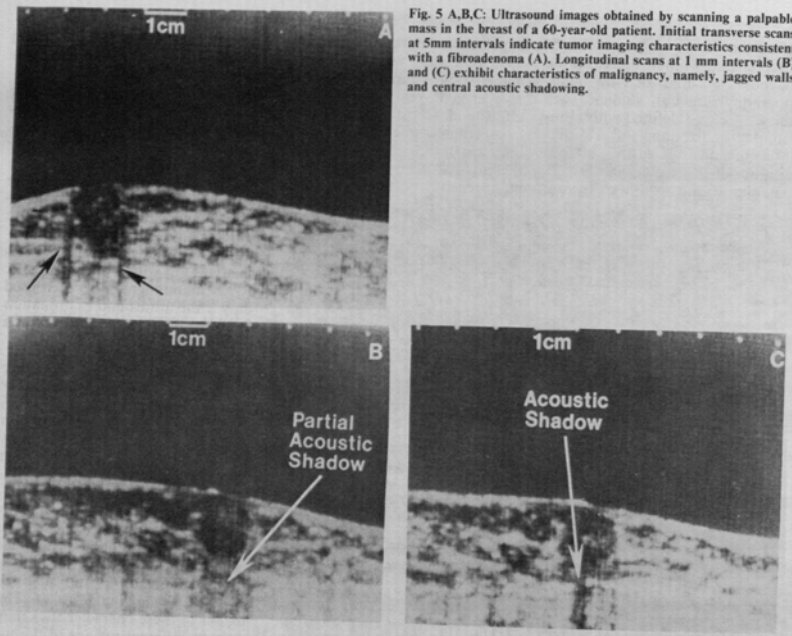


Fig. 5 A,B,C: Ultrasound images obtained by scanning a palpable mass in the breast of a 60-year-old patient. Initial transverse scans at 5mm intervals indicate tumor imaging characteristics consistent with a fibroadenoma (A). Longitudinal scans at 1 mm intervals (B) and (C) exhibit characteristics of malignancy, namely, jagged walls and central acoustic shadowing.

June 1978 to September 1980. This period reflects the time during which we utilized only transducers developed by the Indianapolis Center for Advanced Research, Inc., and 1 mm interval scanning was incorporated into the instrumentation. There was approximately a six-month interval, prior to June 1978, during which instrumentation modifications and examination techniques were being developed and the technician and radiologist were being trained. More than 200 patients were examined during this initial training phase of the study, and 738 patients were examined in the period discussed in this paper.

Of 34 pathologically confirmed carcinomas, 32 were diagnosed correctly by ultrasound and 32 by mammography. The two incorrect diagnoses by x-ray mammography and by ultrasound were for different patients. The two cases that were missed with x-ray mammography occurred in relatively young patients, i.e., 38 and 40 years old. In both patients there was a large amount of fibroglandular tissue within the breast and, therefore, there was lack of contrast between the clinically palpable mass and the surrounding tissue. These masses were correctly diagnosed as malignant by ultrasound.

In one of the cases incorrectly diagnosed by ultrasound, which occurred very early in this study, there was an interpreter's error in evaluating the mass and, in retrospect, this lesion should have been diagnosed as a malignant neoplasm. The other missed diagnosis was for a mass located at the most lateral aspect of the breast, and this area, in error, was not scanned. The carcinomas diagnosed were predominantly of the infiltrating ductal type; however, a few lobular, two medullary, one colloid, and a clear cell papillary carcinoma also were found.

There were seven false-positive diagnoses for malignancy made by ultrasound and four false-positives by x-ray techniques. These pathologies consisted of varying forms of dense tissue deposits, fat necrosis, dense fibrous tissue and diffuse papillomatosis. This result indicates a low number of false-positives for both x-ray mammography and ultrasound. Since patients who received a negative diagnosis were not biopsied, it is not possible to give our results in the classical terms of "sensitivity" and "specificity." It may be useful, however, to mention here results obtained by Manoliu and Ooms in their study of the accuracy of mammography in a symptomatic patient population of 609 women (655 breasts) with a total of 224 histologically confirmed malignant tumors.[5] All patients in that series received a biopsy and, on the basis of those data, it was determined that there were 85 false-positive cases, yielding a *specificity* of 80.3%, and there were 13 false-negative cases, yielding a *sensitivity* of 86.6%.

In patients with benign pathologies, fewer biopsies have been performed, possibly because of the young age of the majority of these patients. Eighty-eight patients have been diagnosed by ultrasound techniques as having benign solid masses, the appearance of which was compatible with a fibroadenoma. Of these, 18 were pathologically confirmed. Most of these 18 patients were over 40 years of age. The patients who were not biopsied are being followed closely with both clinical and ultrasound examinations.

Approximately 159 patients were diagnosed as having fibrocystic disease in the same time period. Twenty-eight of these patients have had confirmatory biopsies, and the rest are being followed both clinically and with ultrasound.

Four cases of cystosarcoma phylloides were encountered in this same period, and all of these were correctly diagnosed by ultrasound. One other case was diagnosed as "malignant" cystosarcoma phylloides, but pathological study proved it to be a rare neoplasm, i.e., clear cell papillary carcinoma.

Discussion

Although multiple investigators in various parts of the world have used ultrasound for visualization of the breast with good results and diagnostic criteria have been described which allow the distinction between benign and malignant masses, ultrasound visualization has not been widely used on a routine, clinical basis for breast examination.[3,6-13] In this study, specifically designed for the symptomatic patient, ultrasound visualization has shown clear advantages for breast examination. For the older patient, some of the advantages are associated with gaining more information on malignant tumor characteristics, which can be used in conjunction with that provided by x-ray mammography to yield increased diagnostic accuracy.

It is noteworthy that, in this study, when both the x-ray mammography and the ultrasound data were taken into account, no malignant masses were misdiagnosed. The two cases that were misdiagnosed by x-ray mammography were typical of the type most often misdiagnosed with this technique, namely, young dense breasts showing poor contrast between the malignant mass and the surrounding tissue. These masses were correctly diagnosed by ultrasound visualization. It also is significant that the two masses not correctly diagnosed by ultrasound were in error for reasons not associated with the validity of the technique, that is, in one case (which occurred very early in the series) there was an interpreter's error of the image data, and in the other case, the region of the palpable mass was not scanned by the technician.

Insofar as false-positive results are concerned, dense masses such as fat necrosis or dense fibrous tissue, which may simulate the image characteristics of a malignant tumor on x-ray mammography, also are open to misdiagnosis by ultrasound visualization since these dense but benign masses may attenuate the sound beam. However, according to our ongoing studies, it appears possible to correctly differentiate such dense benign masses from malignant tumors by studying their attenuation characteristics in relation to frequency.[3,14]

Unlike x-ray imaging, ultrasound can image both cystic and solid masses in the dense breast with great clarity; therefore, for the younger patient with a fibrocystic breast or other benign breast pathology, ultrasound usually provides an accurate diagnosis without the accompanying use of x-ray mammography and, in many cases, eliminates the need for a biopsy.[2] Additionally, this modality can be used repeatedly on the same subject without any known damaging or cumulative effects to either follow the normal time course of benign pathology such as fibrocystic disease, or to observe the effect of some prescribed course of therapy.

In our program, we have found that certain techniques are essential for correct diagnosis. One of the most important is that each mass is scanned at step intervals of 1 mm. It is not uncommon to find in past and some current ultrasound breast examination programs that scans are carried out primarily over the central region of the mass or, if the mass is completely scanned, large step intervals such as 5 mm are used. The use of techniques that allow only a small volume of the mass to be examined partially accounts for some of the failures in

the past regarding the misdiagnosis of malignant tumors by ultrasound techniques.[3] The importance of examing masses as closely as possible is illustrated in *Fig. 5*. Large interval scanning reveals a mass that appears to be benign, whereas, 1 mm interval scanning demonstrates the malignant characteristics of the neoplasm.

Conclusion

On the basis of the results that have been obtained over the last three years in our ultrasound breast program, we recommend that ultrasound be the initial imaging examination for the young patient and for patients of all ages with fibrocystic disease. In the older patient with a suspicion of malignancy, x-ray mammography combined with ultrasound should be used because this approach significantly improves diagnosis.

REFERENCES

1. P Harper, E Kelly-Fry: Ultrasound visualization of the breast in symptomatic patients. *Radiology*, 137 (2):465-469, 1980.
2. AP Harper, E Kelly-Fry, JS Noe: Ultrasound breast imaging—The method of choice for examining the young patient. *Ultrasound Med Biol*, 7:231-237, 1981.
3. E Kelly-Fry: Breast imaging. In Sabbugha RE (ed): *Diagnostic Ultrasound in Obstetrics and Gynecology*. Vol. 24. New York, Harper and Row, 1980, pp 327-350.
4. JP Minton, *et al*: Caffeine, cyclic nucleotides and breast disease. *Surgery*, 86 (1):105-109, 1979.
5. RA Manoliu, GH Ooms: The accuracy of mammography. *Radiolog Clin*, 46:422-429, 1977.
6. T Kobayashi: Review: Ultrasonic diagnosis of breast cancer. *Ultrasound Med Biol*, 1:383-391, 1975.
7. G Baum: Ultrasound mammography. *Radiology*, 122:199-205, 1977.
8. T Wagai, M Tsutsumi: Ultrasound examination of the breast. In Logan WW (ed): *Breast Carcinoma: The Radiologists Expanded Role*. New York, John Wiley and Sons, 1977, pp 325-342.
9. J Jellins, G Kossoff, TS Reeve: Detection and classification of liquid filled masses in the breast by grey scale echography. *Radiology*, 125:205-212, 1977.
10. J Jellins, TS Reeve: Breast echography compared with xerography. In White D, Lyons EA (eds): *Ultrasound in Medicine*. Vol. 4. New York, Plenum, 1978, pp 313-318.
11. T Kobayashi: Current status of breast ultrasonography and ultrasound tissue characterization of breast cancer. In Lindbergh/Kaihara (eds): *MED INFO 80*. North-Holland Pub. Co., 1980, pp. 205-209.
12. C Cole-Beuglet, *et al*: Ultrasound mammography. *Radiologic Clinics of North America*, 18 (1):133-143, 1980.
13. VG Matura, *et al*: Ultrasound of the whole breast utilizing a dedicated automated breast scanner. *Radiology*, 137 (2): 457-463, 1980.
14. E Kelly-Fry, P Harper, GW Gardner: Possible misdiagnosis of sound attenuating breast masses detected by ultrasound visualization techniques and solutions to the problem. In *Proceedings*, 23rd Annual Meeting of AIUM, 1978, p. 129.