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A PRELIMINARY ANALYSIS OF THE ULTRASOUND IMAGING CHARACTERISTICS OF MALIGNANT BREAST MASSES AS COMPARED WITH X-RAY MAMMOGRAPHIC APPEARANCES AND THE GROSS AND MICROSCOPIC PATHOLOGY†

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Abstract—Thirty correctly diagnosed carcinomas were chosen for retrospective analysis of their ultrasound and X-ray imaging characteristics, and correlated with pathologic examination. It was determined that the ultrasound image correlated well with that revealed by radiographic techniques. The posterior attenuation shadow and the jagged wall were the prime indicators of malignancy in this study, occurring in 90 and 87% of the cases, respectively. However, in about 67% of these masses, attenuation shadowing was revealed only by close-interval (1 mm) stepwise scanning. A non-homogeneous internal echo pattern was found in 73% of the cases. Thirteen of the 30 masses showed disturbed architecture away from the overt lesion when imaged by ultrasound techniques. Seventy per cent of these showed histological abnormalities in remote regions. Finally, it was shown that the attenuation shadowing exhibited by malignant breast masses is related to the collagen content of the lesion, expressed as fibrosis.

Key Words: Breast neoplasm, Ultrasound breast diagnosis, Ultrasound mammography, Ultrasound breast imaging.

INTRODUCTION

The combined application of both X-ray mammography and ultrasound breast imaging provides a unique opportunity to discover clues that are important to the diagnosis of malignant breast masses. (Teixidor and Kazam, 1977; Harper and Kelly-Fry, 1978, 1980; Cole-Beuglet *et al.* 1981; DeGezelle *et al.* 1981). This study is a preliminary evaluation of the various diagnostic criteria commonly used in ultrasound breast imaging and the relation of these to criteria used in the X-ray mammographic diagnosis of malignancies. The possible histopathologic bases for these images are also considered. The criteria for differentiating between malignant and benign solid masses are considered in a follow-up study to this investigation. (Harper *et al.* 1982).

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INSTRUMENTATION

The ultrasound instrument, developed by the Indianapolis Center for Advanced Research, Inc., is a simple *B*-mode linear scan unit with video scan converter which provides, by means of a motor-driven transducer, static images of the compressed breast of a supine subject. Stepping intervals between scans of 5 or 1 mm can be chosen. An *f*/2, 3.7 Mhz transducer with an axial resolution of 0.8 mm, 6 dB beam width of 1.2 mm, and a fractional bandwidth of 27% was applied to most of the patients in this study. Images from the scanner are recorded in multi-image format on 8×10 in. radiographic transparency film.

The automatically controlled probe is immersed in a water bag constructed of thin, transparent polyester sheeting. This material readily contours to the breast and allows visual inspection of the skin surface during a scan. Angulation of the supine patient by pillow or foam wedge, plus the capability of

orienting the scan head of the instrument transversely, longitudinally, or diagonally, in combination with the compression effects of the 1.8 liters of water, provides for almost normal incidence of the sound beam to the region of interest.

X-Ray mammograms are performed using low dosage film/screen techniques. A dedicated mammographic X-ray machine is employed which utilizes a microfocus tube system with a tungsten target at a 45° angle. The focal spot size is approx. 100 μm, which allows the use of magnification techniques. Kodak Ortho M film with Kodak Min-R screens are utilized for all X-ray mammograms.

METHODS

Of approx. 1300 symptomatic breast patients, 43 had masses which were proven malignant by pathology examination. A diagnostic accuracy of 95% was achieved by each technique, X-ray mammography and ultrasound imaging, for these 43 cases. When the information from both modalities was taken into account, there were no missed diagnoses. Thirty cases which had been biopsied at our institution, and for which histology and other required information were readily available for re-evaluation, were chosen for retrospective analysis of their ultrasound, X-ray and pathology characteristics. These masses ranged in size from 1.0 to 8.0 cm, with a median value of 2.1 cm. Patients referred to our institution were not included in this study, since pathology specimens were not always readily available. The 30 chosen cases had been correctly diagnosed by ultrasound imaging upon initial examination. This was also true for the 29 cases that received X-ray mammography.

X-Ray and ultrasound films were re-read by a senior radiologist highly experienced in reading breast ultrasound and X-ray images, and by two junior radiologists, each with 1 month of prior training in reading ultrasound and X-ray breast images. Only minor discrepancies between the readings of these three individuals occurred, and these were resolved by all three reviewing the films and reaching a mutual decision. Histological data were obtained by a senior pathologist experienced in breast diseases.

The information obtained from this re-reading of the images and that obtained from the pathology data was coded into a machine-readable format and fed into a computer so that cross-tabulation could be quickly made and exact comparisons between the ultrasound, X-ray and pathology data could be quickly drawn.

RESULTS

As shown in Table 1, the majority of carcinomas in this study were of the ductal type.

Table 1. Pathology classification of 30 carcinomas studies by ultrasound and X-ray

Histological type	Number	Percent of total
Ductal	25	83
Medullary	2	7
Other†	3	10

†One each of lobular, clear cell papillary and signet ring cell carcinoma.

Ultrasound criteria used by some investigators for diagnosing breast malignancies are: (1) irregular or spiculated contours; (2) inhomogeneous internal echoes; and (3) attenuation shadowing posterior to at least some areas of the mass (Kobayashi, 1975; Kelly-Fry 1980). X-Ray imaging criteria are chiefly irregular or spiculated contours, and increased density relative to the surrounding tissue. (Wolfe, 1967; Egan, 1972).

The wall structure of the lesions were recorded as either smooth or irregular, when imaged by ultrasound. In 87%, the masses showed an irregular or jagged wall structure, and in 13% a smooth one. In three cases, the tumor mass was not well enough visualized on X-ray mammography to allow a determination of wall contour, and one case did not have X-ray mammography prior to biopsy. Wall structure is a characteristic that can be evaluated by both X-ray mammography and ultrasound imaging techniques and, as shown in Table 2, excellent agreement (approx. 96%) between the two modalities was obtained in this study.

Seventy-three per cent of the cases studied illustrated an inhomogeneous internal echo pattern: in 20%, the internal echo pattern was not visible due to attenuation shadowing; the pattern was considered homogeneous in only 2 malignancies (7%).

The differential diagnosis of a breast mass by ultrasound examination depends on attenuation effects, as well as the previously discussed criteria of wall structure and echo pattern, (Kelly-Fry 1980). Ninety per cent of

Table 2. Comparison of wall structure contours as visualized by ultrasound and X-ray mammography

	Mammographic characteristics		
Ultrasound characteristics	Smooth	Ragged	Not evaluated
Smooth	3	1	0
Ragged	0	22	4
Not evaluated	0	0	0

malignant tumors examined in this series exhibited attenuation shadowing when the entire tumor was examined with close-interval (1 mm) scanning. However, two-thirds of these masses exhibited attenuation shadowing over only a portion of the lesion. (Harper and Kelly-Fry, 1980; Kelly-Fry 1980). Three malignant masses did not exhibit attenuation shadowing, but these cases demonstrated other characteristics associated with malignancies, such as non-uniform internal echoes and a markedly irregular wall structure.

In order to determine whether a disturbed architectural pattern, as imaged by ultrasound, accompanies malignant masses, review of the ultrasound imaging data also included evaluation of the breast tissue adjacent to the mass. These imaging characteristics were then compared to pathological findings. In only 13 cases was there sufficient data for adequate correlation. In 70% of these 13 cases, the ultrasound images showed a disturbed architectural pattern. Histological examination of these areas revealed abnormalities such as fibrosis, inflammation, and fibrous mastopathy.

Some previous investigators have correlated the collagen content of tissue with the degree to which tissues attenuate sound transmission, (Fields and Dunn, 1973; O'Donnell *et al.* 1978; Goss *et al.* 1979; Kobayashi 1979). In this study an attempt was made to determine if the degree of attenuation shadowing correlated with the relative amount of tumor collagen, as determined by the pathologic techniques. The collagen content, described by the pathologist as fibrosis, was evaluated in regard to the extent of the fibrosis throughout the mass, as well as in proportion to the total volume. Tumors were considered markedly fibrotic if 75–100% of the mass showed fibrosis; moderately fibrotic if 50–75% of the mass showed collagenous tissue; and mildly fibrotic if less than 50% of the tumor showed collagen. Table 3, showing the degree of fibrosis cross-tabulated against the degree of attenuation shadowing, would appear to corroborate the findings of previous investigators.

SUMMARY

In summary, it has been shown in this preliminary study that ultrasound images of wall structure of malignant breast masses are apparently directly comparable to the X-ray images of the same masses. Eighty-seven per cent of the malignant masses in this study showed a jagged wall structure by both imaging modalities.

Ninety per cent of the malignancies exhibited some degree of attenuation shadowing. This shadowing appears to be related to the collagen content of the mass, expressed as fibrosis, as determined by the pathologist.

Seventy-three per cent of the malignant masses exhibited inhomogeneous internal echoes.

For 13 malignant breast masses which in-

Table 3. Degree of fibrosis determined by pathology examination compared to attenuation shadowing exhibited by malignant masses examined by ultrasound mammography

	Degree of fibrosis	
Attenuation shadowing	Marked to moderate	Mild
Marked to moderate	18	2
Mild	4	3
None	2	1

cluded ultrasound imaging of the areas surrounding the tumor, and which had a biopsy sufficient to allow microscopic analysis of this region, 70% showed a disturbed architectural pattern in non-tumorous areas of the breast, and these same areas exhibited abnormalities under histological analysis.

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