Ultrasound in the Evaluation of Solid Breast Masses

Applying specific ultrasound instrumentation and experimental techniques in a study of approximately 1300 patients with breast lesions, we found it was possible to differentiate benign and malignant masses with a high degree of accuracy (1). The ultrasound diagnosis was confirmed by pathologic study in 95% of the 43 malignant masses found in that population. In reviewing these data, we thought it would be of value to make a careful analysis of the ultrasound image characteristics that are heavily weighted by physicians when making a diagnosis on the basis of the ultrasound images, and to compare the radiographic and ultrasound image data for those patients that were examined by both modalities. In order to accomplish this, we evaluated the principal imaging factors used for diagnosis in a retrospective analysis of 72 solid masses (41 malignant and 31 benign) that had been correctly diagnosed by ultrasound imaging and proved by biopsy.

MATERIALS AND METHODS

Instrumentation

The ultrasound instrument used was developed by the Indianapolis Center for Advanced Research, Inc. It was a B-mode linear scan unit and provided close-interval (1 mm) static images of the compressed breast with the patient in a supine position. Motor-driven f2, 3.7-MHz transducers with an axial resolution of 0.8 mm and a 6-dB beam width of 1.2 mm were used. The sound intensities of the two separate 3.7-MHz transducers applied in this study were: at the transducer face, 0.25 mW/cm² and 0.44 mW/cm²; at the focus (20-dB beam width), 25 mW/cm² and 110 mW/cm². The transducer was immersed in a transparent polyester water bag that readily adapted to the contours of the breast surface, providing constant compression and allowing visual inspection of the skin surface during scanning. The transducer could scan transversely, longitudinally, or diagonally at either 1-mm or 5-mm intervals. The flattening of the breast by the water bag, in combination with orientation of body position, provided close to normal incidence of the sound beam to the region of interest.

Using low-dose techniques, x-ray mammograms were obtained of 62 of the patients. The highest possible radiographic contrast was obtained by the use of a dedicated mammographic x-ray machine using a microfocus x-ray tube system with a focal spot size of approximately 100 μm. Kodak Ortho M film and Kodak Min R screens were used.

Methods

The ultrasonic imaging characteristics evaluated were: the size of the mass, recorded as the largest diameter in centimeters; the wall structure, defined as being either well demarcated from the surrounding tissue or not, and as either smooth or jagged; the degree of attenuation shadowing (marked, moderate, or slight), judged by the "blackness" of the shadow and not dependent on its width, and the
RESULTS

Wall Structure
The walls of the section of the wall structure of all of the malignant masses could be sufficiently visualized by ultrasonic technique. Malignant masses were distinguished based on the following characteristics:

- Ductal carcinomas (the most common type of breast malignancy) represented 80% of the malignant masses in this study. The results given for the general class of malignant masses are, therefore, weighted in favor of ductal carcinomas. The results specific to ductal carcinomas are also indicated. In view of the absence of a statistically adequate representation of these masses for the pathologic categories, it was decided that conclusions based on cross-tabulation data relating size of these masses and the image characteristics were not warranted.

Pathology Diagnosis

<table>
<thead>
<tr>
<th>Pathology Diagnosis</th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductal carcinomas</td>
<td>19</td>
</tr>
<tr>
<td>Lobular carcinomas</td>
<td>7</td>
</tr>
<tr>
<td>Adenofibromas</td>
<td>9</td>
</tr>
<tr>
<td>Fat necrosis</td>
<td>2</td>
</tr>
</tbody>
</table>
| Mild to moderate ductal change | 10
| Other                | 1               |

Maximum diameter of benign masses retrospectively analyzed for their ultrasonic imaging characteristics. Of the total of 36 masses analyzed, none could be treated due to their diffuse nature. The histologic type of benign lesions encountered in this study are also shown.

Figure 1

- Histogram showing distribution of malignant masses diagnosed by ultrasonic imaging.
- Maximum diameter of malignant masses.

Figure 2

- Histogram showing distribution of benign masses diagnosed by ultrasonic imaging.
- Maximum diameter of benign masses.

3. Ductal carcinoma in a 35-year-old woman. The ultrasonic image demonstrates a markedly irregular wall (arrow).

4. Ultrasound image of a fibroadenoma (arrow) in a 18-year-old patient. The image exhibits smooth walls and a homogeneous internal echo pattern. Slight posterior echo enhancement is noted. Enhancement of echo amplitude posterior to a mass is not unusual for low-density lesions.

Internal Echo Pattern
A homogeneous internal echo pattern was found in only 12% of the malignant masses; 7% of these masses exhibited nonhomogeneous internal echoes. In 17% of the malignant masses, the internal echo pattern was not discernible, generally because of the marked attenuation effects of the tumor. In 17% of masses with nonhomogeneous internal echoes were excluded, then the internal echo pattern was nonhomogeneous in 85% of the cases. For ductal carcinomas, the internal echo pattern could not be definitively imaged in 18% of the cases, was nonhomogeneous in 70%, and was homogeneous in 12% of the cases. Additionally, many of the ductal carcinomas plane; whereas with ultrasound the lesions are being examined in tomographic planes (3) (Fig. 5).

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exhibited low-intensity echoes. A nonhomogeneous internal echo pattern is illustrated in Figure 6.

A homogeneous internal echo pattern is more characteristic of the benign breast mass (4) and, in this study, was found in 71% of the benign cases. Thirteen percent of the benign masses exhibited nonhomogeneous echoes. In 16% of the benign masses, the images of internal echoes could not be adequately evaluated, either because too few echoes were imaged or they were not imaged in sufficient clarity. However, only one fibroadenoma exhibited this characteristic. Since the other benign cases consisted of fibrocystic disease, fat necrosis, and florid intraductal papillomatosis, it is probable that the failure to image internal echoes adequately in these cases was associated with attenuation effects of fibrous or necrotic tissue. If such cases are eliminated and only masses for which adequate imaging was obtained are evaluated, then 85% of benign masses exhibited homogeneous echoes.

Eighty-nine percent of fibroadenomas exhibited a homogeneous internal echo pattern. A typical textured pattern is shown in Figure 4. In one fibroadenoma mass, the echo pattern was not well visualized, and in another a nonhomogeneous internal echo pattern was present. This latter mass occurred in a 35-year-old patient and showed a transonic area that may have represented a small area of degeneration within the mass. Fibroadenomas that do not spontaneously recede eventually tend to undergo atrophy, hyalinization, and calcification (3). Nonhomogeneous internal echo patterns were found in only three other benign masses: a breast abscess, a foreign body response, and fibrosis.

**Figure 8**

**Attenuation Characteristics**

For the primary ultrasound frequency used in this study (3.7 MHz), attenuation shadowing was found to be a significant feature for diagnosis. Ninety-three percent of the malignant masses exhibited shadowing either through a portion or throughout the entire volume of the lesion, and this shadowing was marked to moderate in 73% of these cases. For well over half of the cases, the attenuation effect was not evident over the full volume of the mass, rather, it was associated with only a small volume of the mass (.6). This means that scanning at large increments (3-5 mm or greater) could have resulted in missing this characteristic in 25 masses (6%) that proved to be malignant. A typical example of attenuation shadowing posterior to a malignant mass is demonstrated in Figure 7. Figure 8 is an example of a mass that exhibits shadowing in only a narrow region. Ninety-seven percent of ductal carcinomas exhibited attenuation shadowing, with 79% of these being marked to moderate; the attenuation effect was present in only a portion of the tumor in 64% of the cases. The malignant masses that demonstrated no acoustic shadowing were a necrotic ductal carcinoma, a medullary carcinoma, and an intraductal carcinoma.

In approximately 85% of the benign masses there was no demonstrable acoustic shadowing, in 16% very slight shadowing, and in 9% there was marked to moderate shadowing. Three of these latter masses, which consisted of either fibrocystic disease, fat necrosis, or foreign body response, demonstrated a dense shadow throughout the entire volume of the tumor. Kelly-Fry et al. (7-9) have previously reported the phenomenon of attenuation shadowing posterior to benign masses. In some cases of fibrocystic disease the highly echogenic fibrous tissue superior to the shadow, along with an ill-defined mass, alerted one to the diagnosis; this is demonstrated in Figure 9.

For fibroadenomas masses, slight attenuation shadowing could be discerned in 17% of the cases, but for the majority of cases (67%) no attenuation shadowing was evident. Thirteen percent demonstrated marked to moderate shadowing in a small portion of the mass, but no fibroadenomas showed shadowing over the entire volume. The lateral shadow has been described by many previous authors as one of the characteristics of a benign mass (10-12). In our study, the lateral shadow sign was present in only 35% of benign masses, and was also found in 15% of malignant masses. The presence of this feature was not significant in this study for differentiation of benign from malignant masses.

**DISCUSSION**

The large percentage of malignancies in our study that demonstrated shadowing (30%) is in contrast to some previously published data of Fields (13) and of Lerro et al. (14). Fields (13) found attenuation shadowing in only 43% of breast malignancies. Lerro et al. (14) found that only 30% of the scirrhous masses showed shadowing, for other classes of malignant masses the percentage figure for attenuation shadowing was much less. The discrepancy may be due to the fact that, in our study, acoustic shadowing was determined by measuring millimeter by millimeter for the presence of this phenomenon in all regions of the mass. Kobayashi found that 83% of malignant masses, and 100% of scirrhous tumors, exhibited attenuation shadowing (15). The fact that 29% of benign masses were found to exhibit moderate to marked shadowing clearly indicates that attenuation shadowing is not restricted to malignant masses. Kelly-Fry et al. (7) have pointed out that in the "double pass" of the sound beam in pulse-echo methods, an attenuation shadow can result for some benign masses when they are imaged at commonly applied sound frequencies. In order to evaluate the benign vs. malignant character of a wild breast mass by ultrasonic imaging, attention must be paid to several imaging characteristics rather than any single characteristic. The evaluation of wall characteristics, attenuation shadowing, and internal echo pattern, together with the patient's clinical history, is usually sufficient for accurate diagnosis. The entire volume of the mass must be scanned at close intervals (1 mm) for adequate evaluation to be accomplished.

Analysis of the data in this study for the most common malignant breast mass, the ductal carcinoma, showed that the images of these masses exhibited a jagged wall in 98% of the cases, nonhomogeneous echoes in 70% of the cases, and homogeneous echoes in only 12%; 18% could not be visualized due to attenuation effects, and posterior shadowing was present in 43% of the cases. In 85% of the cases, the internal echoes were either nonhomogeneous or so attenuated they could not be imaged. By contrast, images of the most common solid benign tumor found in the young breast, the fibroadenoma, exhibited smooth walls in 94% of the cases, homogeneous internal echoes in 89% of the cases, and no demonstrable attenuation shadowing in 57% of the cases. In view of similarities between medullary carcinomas and fibroadenomas (16, 17), as well as the rare possibility of a fibroadenoma-like mass harboring a malignancy, extreme care must be taken in documenting all of these characteristics for the full volume of the mass. The two-mass clumping phenomenon encountered in this study demonstrated a slight jagged appearance of the wall structure and a mark-
edly nonhomogeneous internal echo pattern, and one of the masses showed enhancement of echoes posterior to the mass.

SUMMARY

A retrospective analysis of the ultrasonic imaging characteristics of pathologically proved solid benign and malignant masses showed that specific ultrasonic imaging characteristics predominate in certain breast pathologies. The wall contour of breast masses, as visualized by ultrasonic imaging, is a significant feature for diagnosis and correlates well with the radiographic characteristics; malignant masses predominantly exhibit the jagged wall structure, and the most common solid benign mass in the young breast, the fibroadenoma, is typically a smooth-walled structure. The texture features of the mass, as characterized by the internal echo pattern, are predominantly nonhomogeneous in the malignant mass, and homogeneous in the benign mass. Alternative shadowing may be present in the images of both the benign and malignant mass, but it is a much more common feature of the malignant mass (by a factor of two), and a greater degree of shadowing is generally present in the images of malignant masses. Adequate appreciation of these features will result if an instrument is used that provides good imaging of the fine structure of the breast tissue and if the entire volume of the mass is examined at close intervals.

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References