US DIAGNOSTIC CRITERIA

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**Introduction**

The ultrasonic diagnostic equipments for the breast have been remarkably developed in this decade, the diagnostic criteria has been improved by many investigators. Especially, the development of real-time echography and colour Doppler have brought new techniques and new findings. In this chapter, I will explain the new real-time diagnostic criteria grounded on the basic concept of ultrasonic tissue characterization.

**Ultrasonic Tissue Characterization**

Beginning with the interpretation of echograms, we should understand the ultrasonic tissue characterization of breast tumours. Invasive ductal carcinoma is subdivided on the basis of the amount of diffuse fibrous stroma, or by the growth pattern as stellate or circumscribed. Stellate carcinoma has a stellate appearance with an ill-defined edge, infiltrating the adipose tissue of the breast. It has a spicula formation and abundant fibrous stroma. Circumscribed carcinomas are characterized by a well-delimited, rounded, lobulated or multinodular contour and has a pushing border and shows an expansile type of growth. On the other hand, there is relationship between fibrous tissue and ultrasonic attenuation. Fibrous tissue attenuates the ultrasound, while fluid dose not attenuate ultrasound so much. Therefore, all mass image forming type can be divided into three categories: the attenuating type, the accentuating type and the intermediate type, on the basis of the degree of ultrasonic attenuation without regard to malignancy and benignity. These types are defined as follows;

**Attenuating type** means masses with weak or absent posterior echoes due to high attenuation of the sound waves passing through them.

**Accentuating type** means masses in which the posterior echo intensity is enhanced due to a low degree of attenuation.

In the **Intermediate type** the attenuation is the same as the surrounding breast tissue. The ultrasonic pattern is so related to fibrosis that this classification is very important to understand morphology of breast tumours. The feeding arteries which exist at the tumour
margins or in the surrounding tissues are usually detected in malignant cases. The visualization of tumour vessels is more specific to distinguish cancer from benign lesions than that of feeding arteries. There is a correlation among vascularity, ultrasonic and histological types. The accentuating types show hypervascularity, while the attenuating type which represents scirrhous carcinoma shows hypovascularity. The vascularity is made mention minutely in the chapter of colour flow imaging.

**Attenuating Type**
Carcinoma growing in stellate fashion like scirrhous carcinoma has abundant stroma which mainly consists of fibrous tissue and represents the attenuating type. It shows an irregular border, lateral dense boundary echoes (echogenic halo) owing to the spicula and composite including normal tissue and cancer tissues at the surface where ultrasound waves are scattered back. Although fibroadenoma usually shows enhanced posterior echoes, a matured type of fibroadenoma that is abundant in collagen fibers, produces an acoustic middle shadow sign similar to that of scirrhous carcinoma. Matured fibroadenomas in which acoustic impedance differs greatly from that of surrounding tissue, and which are smooth and either round or oval, show high anterior echoes because of low incident angles. Fibroadenomas have internal echoes which are heterogeneous due to irregular calcification; therefore, internal echoes are not important findings and also the DW ratio, which represents elasticity or compressibility, is not significant findings since both malignant and benign tumours of this type are very hard. Having the advantage of real-time, dynamic tests have been developed to investigate compressibility and mobility. Although both malignant and benign tumours are very hard, the malignant attenuating type fixes to surrounding tissues which can be visible by dynamic tests. As this type tumour has a tendency to occur in old female, who has a thin mammary gland, the surface of mammary gland is easily interrupted by invasion and the superficial layer of the superficial fascia is disrupted.

Neovascular vessels are detected in 85% of accentuating type carcinomas, and 90% of them had more than 2 feeding arteries, while the attenuating type tends to be hypovascular. All attenuating type tumours which have no neovascular vessels or less than one feeding artery were scirrhous carcinoma. If exist, the feeding arteries of cancer go directly in the tumour mass, while that of fibroadenoma run around tumour.

**Accentuating type**
The ultrasonic attenuation by cancer cells is not as strong as collagen fibers.
Accentuating posterior echoes suggest that tumours contain a lot of water or cellular components rather than fibrosis. The ultrasonic attenuation by circumscribed carcinoma may be small, because it is rich in cancer cells. Its echogram, therefore, shows accentuated posterior echoes.

DW ratio is related to compressibility, mobility and direction of tumour growth. This ratio is very useful for cases of the accentuating type. DW ratio of a benign accentuating type is usually less than 0.7 under natural pressure at the supine position. This is due to its high compressibility and high mobility. However, the DW ratio of the malignant accentuating type is more than 0.7, because the cancers are hard and fixed to the surrounding tissues. Cancer of this accentuating type shows heterogeneous internal echoes, a lobulated shape and high DW ratio. Although the relative mobility of malignant cases of the accentuating type is not as restricted as in the attenuating type, tumours are fixed to surrounding tissues due to invasion and can not be deformed by compression.

Fibroadenoma, representative of benign tumours, have an oval shape, homogeneous internal echoes and these are easily deformed by compression. Although both malignant and benign accentuating types are hypervascular, malignant type shows tortuous running and mosaic pattern in colour flow imaging, while arteries associated with benign tumours show smooth and monotone colour.

**Intermediate Type**

Intermediate type lesions are the most difficult to diagnose. Malignant tumours in this category are characterized first by their crab-like shape, and then by their irregular border and heterogeneous internal echoes due to calcification. The echoic halo suggests the possibility of malignancy. Mastopathy represents the benign intermediate type. The mass of mastopathy, such as duct papilomatosis or sclerosing adenosis show no change in the posterior echoes in both cases. Its very difficult to distinguish these lesions from cancer, although their smooth border and homogeneous internal echoes suggests that they are benign.
The diagnostic criteria for mass image forming type described in this paper appears in Figure 1.

<table>
<thead>
<tr>
<th>ATTENUATING TYPE</th>
<th>INTERMEDIATE TYPE</th>
<th>ACCENTUATING TYPE</th>
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<tbody>
<tr>
<td>MALIG.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectangular</td>
<td>crab-like shape</td>
<td>lobulated shape</td>
</tr>
<tr>
<td>echogenic halo</td>
<td>heterogeneous</td>
<td>heterogeneous</td>
</tr>
<tr>
<td>not mobile</td>
<td>internal echoes</td>
<td>internal echoes</td>
</tr>
<tr>
<td>hypovascular</td>
<td>calcification</td>
<td>large DW ratio</td>
</tr>
<tr>
<td>direct in vessel</td>
<td>dilated duct</td>
<td>incompressible</td>
</tr>
<tr>
<td></td>
<td>hypervascular</td>
<td>mosaic vessel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tortuous vessel</td>
</tr>
<tr>
<td>BENIGN</td>
<td>round</td>
<td>oval</td>
</tr>
<tr>
<td>high anterior</td>
<td>ill-defined border</td>
<td>homogeneous</td>
</tr>
<tr>
<td>echoes</td>
<td>echogenic</td>
<td>internal echoes</td>
</tr>
<tr>
<td>mobile</td>
<td>internal echoes</td>
<td>compressible</td>
</tr>
<tr>
<td></td>
<td>hypovascular</td>
<td>surrounding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>marginal artery</td>
</tr>
</tbody>
</table>

Fig.1: Diagnostic Criteria for Mass Image Forming Type

*Non-Mass Image Forming Type*
Since not only breast cancers form a mass image in echograms, we classified breast diseases into the non-mass image forming type and the mass image forming type. The non-mass image forming type is subdivided into 4 patterns; homogeneous pattern, mottled pattern, ductal pattern and multicystic pattern.

*Homogeneous Pattern*
The parenchyma of mammary gland is echogenic or hypoechoic. The girl before menarche shows hypoechoic homogeneous parenchyma because of a lack of acinus which is considered to have echogenecity. Woman more than 35 years old shows homogeneous pattern in normal.
**Mottled pattern**
The mammary gland is thickened and stubbed with hypoechoic areas, 3 to 10 mm in size. Every young woman shows this pattern. This pattern in woman more than 30 years old means mostly mastopathy (fibrocystic disease, dysplasia). Mastopathy is frequently diffuse or multifocal in both breasts. Sometimes we encounter non-invasive cancer which shows a mottled pattern. These lesions are usually localized and the polarity of the hypoechoic area is disturbed. The spotty echoes due to microcalcifications are important findings for diagnosis.

**Ductal pattern**
The lactiferous sinus can be detected as hypoechoic duct in normal breast with religious care. Ductal pattern which means anechoic duct can be seen in the cases of abnormal nipple discharge. If the duct is more than 2 mm in width or extended to periphery beyond the subareolar area, it will be considered to be abnormal. This pattern is caused by intraductal proliferative change for examples; intraductal carcinoma, intraductal papilloma and duct hyperplasia. We tried biopsies for 27 cases of ductal pattern under the guided of ultrasound, and of them 14 cases were histologically verified as early breast cancers. They were non-invasive or microinvasive carcinomas.

**Multicystic pattern**
Multiple cysts are frequently seen in Caucasian breasts for one of findings of degenerative change but not frequent in Japanese. If this pattern can be seen, another breast will show same pattern. It is important not to overlook small carcinomas in attention of large cysts.

**Conclusion**
With the improvement of ultrasonic resolution, breast echography has become more capable of detecting non palpable or mammographically non visualized masses. These understandings will bring more precise diagnosis of breast echography.
References


Tsunoda-Shimizu H., Ueno E., Tohno E. Clinical significance of demonstration of the dilated duct on realtime echogram in cases of abnormal nipple discharge. JSUM proceedings 54:295-296, 1989


PATHOLOGY OF DUCTAL CARCINOMA IN SITU

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Previously, ductal carcinoma in situ (DCIS) was an uncommon lesion. However, the widespread use of screening mammography has resulted in a significant increase in the detection rate of DCIS and management of women with DCIS is currently a major issue of concern and a subject of multiple studies. Of critical importance is the fact that the management relies on an accurate diagnosis of DCIS.

**Definition of DCIS**
DCIS is characterized by a proliferation of presumably malignant epithelial cells within the mammary ductal-lobular system, without light microscopic evidence of invasion into the surrounding stroma.

**Qualitative criteria**
Proliferations with high grade cytology (with or without necrosis) qualify as DCIS, regardless of size or quantity of epithelial proliferation.

**Quantitative criteria**

Tavassoli and Norris (1990)
The 2mm size criterion (2mm in aggregate cross sectional diameter) is invoked only in assessing non-necrotic intraductal proliferations with both architectural and cytologic features similar to those of low grade DCIS.

Page and Rogers (1992)
This scheme requires at least two fully involved duct cross sections to make a diagnosis of DCIS.

**Bilaterality of DCIS**
Limited data is available regarding the incidence of synchronous or metachronous bilaterality associated with DCIS. Judging from various reports, probably at least 2.4% to 13% of cases are bilateral.
**Types of DCIS**

In the traditional system for classifying DCIS, based primarily on the architectural pattern of the lesion, the most common types are designated comedo, cribriform, micropapillary, papillary and solid.

1. **Comedo-type DCIS** is described classically as a solid growth of large carcinoma cells with poorly differentiated nuclei, central necrosis with calcification and a high mitotic rate.

2. **Cribriform-type DCIS** is characterized by a fenestrated, sieve-like growth pattern. The cells are typically small to medium in size and have relatively uniform hyperchromatic nuclei. Mitoses are infrequent and necrosis is limited.

3. **Micropapillary-type DCIS** features small tufts of cells that are oriented perpendicular to the basement membrane of the involved spaces and that project into the lumina. The micropapillae lack fibrovascular cores. The cells are usually small to medium sized, and the nuclei show diffuse hyperchromasia. Mitotic figures are infrequent.

4. **Papillary-type DCIS** shows intraluminal projections of tumor cells, that show fibrovascular cores and thus constitute true papillations. On one variant of papillary DCIS, the tumor cells are primarily or exclusively present in a single cystically dilated space (intracystic papillary carcinoma).

5. **Solid-type DCIS** is characterized by the tumor cells that fill and distend the involved spaces and lack significant necrosis, fenestration, or papillations cytologically. The tumor cells may be large, medium, or small.

Less common variants of DCIS include "clining" carcinoma, intraductal signet ring cell carcinoma, and cystic hypersecretory carcinoma.

Some authors believe it is useful to subdivide DCIS into two subgroups - the comedo type and the noncomedo type (which encompasses the other variants). This preference is based on the observation that comedo DCIS appears more malignant cytologically, is more often associated with microinvasion, and more often exhibits biologic markers indicative of high-grade malignant lesions than do the other types. For example, comedo lesions
more frequently lack estrogen receptors, have a high proliferative rate, and exhibit aneuploidy, over expression of the HER2/neu(c-erb-B2) oncogene, mutations of the p53 tumor suppressor gene with accumulation of its protein product, and angiogenesis in the surrounding stroma. Several studies have shown that there is a higher chance of recurrence after conservative treatment with the comedo variant of DCIS compared to the cribriform and micropapillary types. Among DCIS lesions <2.5cm in extent, 19% of those with comedo pattern recurred after tylectomy compared to 10% of cases of cribriform with atypia, and none of 33 patients with the micropapillary DCIS. In general, comedo DCIS recurs more frequently and within a shorter interval compared to the cribriform and micropapillary variants.

**Grading of DCIS**

Above mentioned conventional classification of DCIS was predominantly based on architectural features, which had formed the basis of the separation of hyperplasia and DCIS. A classification which is designed to predict outcome, a grading scheme, must recognize subtypes with significant differences in outcome, must be simple to use, and must be reproducible in clinical practice. The Van Nuys classification of DCIS is the simplest of the three-tiered systems published to date and could be adopted easily into pathology practice in the community.

**Application of Van Nuys Grading Scheme (Table 1)**

- **Nuclear Grading**
  - **Low-grade (grade 1)**
    - Nuclei equivalent to 1-1.5 red blood cell diameters with diffuse chromatin and inapparent nucleoli.
  - **Intermediate grade (grade 2)**
    - Nuclei equivalent to 1.5-2 red blood cell diameters with coarse chromatin and infrequent nucleoli and mitotic activity.
  - **High-grade (grade 3)**
    - Nuclei with diameters greater than 2.5 red blood cell equivalents with vesicular chromatin and one or more nucleoli, and commonly with frequent mitotic figures.
1. Identify the highest nuclear grade
2. Identify comedo-type necrosis
3. Grading is based on the highest nuclear grade identified and the presence, however extensive or limited, of necrosis versus no necrosis

Table 1. Van Nuys Grading Scheme

<table>
<thead>
<tr>
<th></th>
<th>Nuclear grade 1 or 2</th>
<th>Nuclear grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Necrosis</td>
<td>Low grade</td>
<td>High grade</td>
</tr>
<tr>
<td>Necrosis</td>
<td>Intermediate grade</td>
<td>High grade</td>
</tr>
</tbody>
</table>

The recent 15-year status report of the multi-institutional study on conservative surgery and radiation therapy for DCIS has shown that while the lower grade DCIS lesions take a longer time to recur, the frequency of recurrence for these lesions eventually catches up with the high grade lesion. In this study, the comedo and high nuclear grade DCIS had a 12% actuarial local recurrence at 5 years which increased to 18% at 10 years; those DCIS lacking both comedonecrosis and high grade nuclei had a 3% recurrence at 5 years and 15% at 10 years. The low grade DCIS lesions are slow growing and would take a longer period of time to recur even if incompletely excised.

Moreover, there is no question that the precise assessment of the size or quantity of DCIS and the status of the margins are of extreme importance to current management of DCIS in addition to nuclear grade. Sliverstein et al proposed new scoring systems combining three parameters (Table 2).

Table 2. DCIS Scoring System

<table>
<thead>
<tr>
<th>Score</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histology</td>
<td>LG</td>
<td>LG</td>
<td>HG</td>
</tr>
<tr>
<td>Size(mm)</td>
<td>Without necrosis</td>
<td>with necrosis</td>
<td></td>
</tr>
<tr>
<td>Margins(mm)</td>
<td>&lt;15</td>
<td>16-40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1-9</td>
<td>o 1</td>
</tr>
</tbody>
</table>

Score 3,4; Low recurrence rate
5,6; Intermediate recurrence rate
7,8,9; High recurrence rate

4
**Biomarkers in DCIS**

The expression of a variety of biomarkers has been assessed in all variants of DCIS using mainly immunohistochemical techniques. In our experience, expression of c-erb-B2 was correlated with higher nuclear grade of DCIS and expression of ER, c-erb-B2 and Ki-67 PI was significantly associated with histologic grade of DCIS. In low grade DCIS Ki-67 PI was significantly higher than ADH. 15.9% of DCIS and none of ADH were aneuploidy.

**References**


Lagios MD, Margolin F, Westdahl PR, Rose MR. Mammographically detected duct carcinoma in situ; Frequency of local recurrence following tylectomy and prognostic effect of nuclear grade on local recurrence. Cancer 1989; 63: 618-624


DOPPLER ULTRASOUND IN BREAST DIAGNOSIS

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Abstract

Modern color Doppler instruments allow to detect flow in microscopic small vessels which are not visible by conventional B-mode. Simultaneous imaging and vascularity detection allows the use of this method for nonpalpable tumors. It must be recognized that Doppler sensitivity is operator and equipment-dependend, which does not allow an uniform interpretation of different results. In a comparison of 70 cancers with different instruments we found significant differences. In low vascularized cancers flow detection required the most sensitive instruments to be used. The variation of vascularity between different tumors makes a routine use still difficult and requires further clinical research. This article describes the results of a prospective study on lesion vascularity in 266 women with a high sensitive color Doppler instrument. Calculations include vessel numbers, flow velocities and indices describing the flow spectrum. The result is, that the number of tumor vessels and the flow velocities are significantly increased in malignancies, but the flow spectrum does not allow a differentiation of tumors.

Introduction

It is well known from pathological and biochemical studies that malignant growth requires an increased vascularity which is stimulated through specific growth factors (1-3). In earlier studies simple continuous wave (CW) Doppler instruments were used to measure tumor vascularity (4-8). The advantage of CW Doppler is a high sensitivity for low flow detection. The disadvantage is the lack of imaging. Therefore it is very difficult to find the increased vascularity around nonpalpable tumors. Due to sound attenuation of the high frequency signal and the lack of imaging, CW Doppler could only be used in superficial organs like the breast.

This method has been used since more than one decade giving an extraordinary knowledge of vascular changes associated with breast tumors. The major finding was that cancers have an increased number of tumor vessels with high frequency-shifts, indicating high flow velocities compared to benign tumors. In contrary to findings in gynecological tumor studies measurements of the flow profile did not show typical differences (7).

Investigations of tumor vascularity became more popular with the recent improvements of modern color Doppler instruments (9-10). Diameters of tumor vessels are below the resolution of B-mode imaging. In general it would be possible to detect tumor vessels with the
sample volume of conventional Duplex equipment. This is very time consuming as these vessels are not visible. The Doppler beam allows only scanning in a one-dimensional direction and the length of the beam is restricted by the sample volume. This makes an three-dimensional survey for tumor vessels almost impossible. Most traditional Duplex systems have Doppler frequencies which are below the frequency of the imaging signal which reduces the sensitivity to detect flow in small vessels (7). After several comparative studies with different equipment (10) we decided to use a high sensitive color doppler instrument for a prospective study of tumor vascularity in 258 breast lesions. The goal of this study was to define valuable diagnostic criteria by statistical analysis of multiple flow parameters.

Color Doppler Findings

Patients with clinical, mammographic or sonographic abnormalities were included in this study. Initially 266 women were examined. To exclude influences caused by contralateral pathologies 8 patients with bilateral disease were excluded. The data analysis is based on 82 carcinomas, 24 fibroadenomas, 59 nonproliferative benign breast diseases (Prechtel grade 1), 23 with proliferations (grade 2) and 15 with proliferative disease and atypia (grade 3). An ATL UM9 HDI with the L 10-5 broadband linear-array transducer was used. The instrument was tuned for high sensitivity to detect low flow signals. The filter was set at 50 - 100 Hz and the pulse repetition rate at 800 - 1000 Hz. The power output was adjusted just below the background noise level.

Every examination started with conventional B-mode scanning. For systematic assessment of the whole breast anatomy patients were examined in supine position to flatten the breast. The whole organ was investigated in sagittal scans with overlapping scanning planes. After this procedure careful records were taken on any area of abnormality. After this procedure abnormal areas were scanned in color Doppler mode and all vessels were recorded. Each vessel was analysed in Duplex mode with measurements of the maximum peak systolic and diastolic flow velocity and flow profiles were analysed by calculation of the resistance indices:

\[ \text{RI} = \frac{S-D}{S} \] (\(S=\text{systolic flow}; \ D=\text{diastolic flow}\)). All tumor vessels were included into the calculations to avoid any operator bias towards a selection of specific flow values. Median values and percentiles of distribution were calculated rather than mean values as some of the data were not normally distributed. The Wilcoxon test was used to test the flow differences for statistical significance.

Results

Benign lesions: Color Doppler detected a median of 2 vessels in 176 benign conditions. The mean blood flow velocity in all tumor vessels was 11.1 cm/s and the maximum flow velocity measured in all tumor vessels was 12.5 cm/s. For the assessment of the total tumor flow we introduced a new measurement by a summarization of all flow velocities measured in each
tumor. This flow value was on average 18.9 cm/s. The mean RI-index was 0.68 and the minimum RI index was 0.64 (table 1).

Carcinomas: Malignant lesions (n=82) had a median number of 8 tumor vessels. No lesion was avascular. The mean blood flow velocity was 18.8 cm/s, the maximum flow velocity was 32.5 cm/s and the sum of all flow velocities was 147.3 cm/s. All of these quantitative flow values had a highly significant difference between benign and malignant lesions (p > 0.0001). The mean RI-index was 0.75 and the minimum RI-index was 0.64 showing no difference compared with the benign lesions (table 2).

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>25%</th>
<th>MEDIAN (50%)</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>vessel number</td>
<td>5</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>mean flow velocity</td>
<td>13.7</td>
<td>18.8</td>
<td>25.1 cm/s</td>
</tr>
<tr>
<td>maximum flow velocity</td>
<td>22.5</td>
<td>32.5</td>
<td>47.3 cm/s</td>
</tr>
<tr>
<td>sum of all velocities</td>
<td>71.3</td>
<td>147.3</td>
<td>266.7 cm/s</td>
</tr>
<tr>
<td>mean RI-index</td>
<td>0.67</td>
<td>0.75</td>
<td>0.81</td>
</tr>
<tr>
<td>minimum RI-index</td>
<td>0.53</td>
<td>0.64</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Table 1. Flow data in 176 benign breast lesions.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>25%</th>
<th>MEDIAN (50%)</th>
<th>75%</th>
</tr>
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<tr>
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<td>5</td>
<td>8</td>
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<tr>
<td>sum of all velocities</td>
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<td>266.7 cm/s</td>
</tr>
<tr>
<td>mean RI-index</td>
<td>0.67</td>
<td>0.75</td>
<td>0.81</td>
</tr>
<tr>
<td>minimum RI-index</td>
<td>0.53</td>
<td>0.64</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Table 2. Flow data in 82 malignant breast lesions.

Discussion

The results prove that there are significant differences of the vascularity in benign and malignant breast tumors. A high sensitive color Doppler instrument was used in this study which enables for flow detection in benign and malignant tumors. This allowed a large
collection of flow data for a statistical analysis. The study was done prospectively with a strict examination protocol to avoid any bias towards the measurement of larger tumor vessels. Therefore all vessels were measured.

There have been several reports about Doppler results in tumor vascularity. Some of the data are confusing. This might be due to the fact that this application is relatively new and some investigators have no sufficient experience. Doppler examinations of tumor vascularity are difficult to perform. The advantage in breast tumor vascularity is, that earlier studies with continuous wave Doppler give sufficient information on the variable vascularity of breast lesions. These results must be recognized if modern color Doppler is used to study flow changes in tumors as the experiences made with this relatively simple method help to avoid poor study designs which don’t allow a sufficient data interpretation.

It was found in this study, that breast tumors have not the characteristic low impedance flow which is found in gynecological cancers. The impedance in arteries of normal breast tissue and in benign tumors is relatively low. Therefore it is unlikely to find major differences compared with malignancies. In contrary it is surprising, that the diastolic flow in breast cancers tends to be decreased which demonstrates a slightly increased flow resistance. However, the calculation of RI-values does not allow to differentiate benign and malignant breast lesions, which is demonstrated in the results of this study.

The presence of color pixels or measurements of vessel diameter in color mode have been reported to allow tumor differentiation. This simplification is not acceptable as our study shows that the presence of vessels is not specific for malignant lesions. With a sensitive instrument and with an accurate tuning flow can be detected in normal tissue and in benign lesions as well. Therefore a quantification is necessary to distinguish between normal and abnormal. Cosgrove has described a method to quantify the amount of color display (9). This allowed a semiquantitative comparison of differences in tissue vascularity. However this method is not easy and needs a standardisation as the amount of color display depends on many different parameters.

In our study we used Duplex measurements to quantify flow in vessels which were detected by the color display. We used different calculations to estimate tissue vascularity. We did not find any significant differences between RI-values in benign and malignant vascularity, whereas the number of tumor vessels, the average and the maximum flow velocity showed a highly significant difference. It was found most accurate for the differentiation of lesions to estimate the total amount of flow in lesions. If all flow velocities are summarized per lesion, this value includes the number of tumor vessels and flow velocities in all of these vessels and is called the FLOW VELOCITY SUM. It seems at this stage to be the most accurate parameter to distinguish between benign and malignant lesions. It must be recognized that this examination technique is time consuming, it requires experience and a high sensitive Doppler instrument and a standardization is very difficult. Therefore it should not yet be considered as a clinical routine method and further studies are necessary to confirm our findings.
Conclusion

The accuracy of ultrasound has improved with the development of high resolution equipment. However, a reliable differentiation is still problematic. Tumor vascularity is a biologic parameter. Earlier studies with CW Doppler at 8-10 MHz transducer frequency allowed a sensitivity for tumor flow detection of 89-94% but this technique does not allow a combination with imaging.

References

MAMMOGRAPHY AND ULTRASOUND CORRELATION

Mary Rickard M.D.
Central & Eastern Sydney Breast Screen Rachel Foster Hospital, Australia

In practice mammography and ultrasound investigations are frequently both used to assess breast lesions. This is because the two investigations typically give complementary information.

Mammography is recommended as the primary tool for

(1) symptoms in women > 35yrs
(2) screening in women > 40 yrs

Ultrasound is recommended as the primary tool for

(1) symptoms in women < 35yrs
(2) symptoms in women who are pregnant or lactating.

Once a lesion has been identified either by screening or by palpation, then its assessment needs to be multidisciplinary and involve, as necessary, imaging (mammography and / or ultrasound), clinical (history and examination), and tissue sampling (cytology and / or core biopsy). This combination of imaging, clinical and tissue sampling constitutes the Triple Test.

With both mammography and ultrasound the levels of diagnostic confidence and accuracy are dependent on the quality of the examinations. Good quality equipment must be used to produce excellent spatial and contrast image resolution. The operator must be skilled so that the area of interest is properly imaged, and the interpreter must be informed so that the correct diagnosis and differential diagnoses are considered.

Breast lesions can be grouped into three main categories – mass lesions, architectural disturbances and calcifications. The features of a lesion can be used to categorise it as benign, malignant or indeterminate in appearance. The same lesion features are of value on both mammogram and ultrasound examination.

These are
1) margins
   - well defined
   - ill defined
2) shape
   - smooth (round, ovoid, macrolobulated)
   - irregular (variable, microlobulated)
3) adjacent tissues
   - displaced
   - interrupted.
Other features such as lesion density on mammography, or lesion echogenicity and through-transmission on ultrasound, are also analysed but are often only of limited value.

The typical mammogram and ultrasound features of a benign mass such as a cyst or fibroadenoma are
1) well defined margins
2) smooth and ovoid shape (fibroadenoma / cyst) or round shape (cysts), with or without macrolobulations
3) adjacent tissues displaced without any other change

Other relatively well-defined lesions need to be considered in the differential diagnosis of these benign appearing lesions including:-
1) phyllodes tumour
2) carcinoma (particularly mucinous/colloid or medullary)
3) mass like DCIS or intracystic DCIS.

The typical features of a malignant mass or architectural disturbance are
1) ill defined margins with or without spiculations
2) irregular, variable shape with or without microlobulations
3) adjacent tissues interrupted and altered.

Lesions which interfere with normal tissue boundaries and planes need to be considered in the differential diagnosis of malignant appearing lesions, including:-
1) radial scar / complex sclerosing lesion
2) fat necrosis and surgical scar
3) haematoma
4) abscess.

The third type of lesion is calcifications. These are typically well seen and analysed with mammography. Ultrasound is not useful for their analysis ie it cannot be used to distinguish benign from malignant forms. However, microcalcifications may be visible on ultrasound examination. If microcalcifications are seen on ultrasound examination then ultrasound can be used, to look for changes suggestive of an adjacent invasive mass, and to guide tissue sampling and preoperative localisation.

Good quality mammography and ultrasound examinations both give complementary information which improves diagnostic confidence and accuracy. However in different situations one diagnostic imaging test may be superior. eg. :

1) mammography should readily demonstrate a small spiculated invasive cancer present in an elderly patient with a largely fatty replaced breast. This lesion may not be easily recognised on ultrasound examination as it is frequently similar in echogenicity to the surrounding fat.
2) Ultrasound should readily identify a palpable fibroadenoma present in a young woman with a glandular breast. This lesion may be difficult to see or even occult on mammography examination as it can be obscured by the dense fibroglandular tissue.

In order to be confident that the same lesion has been identified on both mammography and ultrasound examination, it is critical to correlate the diagnostic features of the lesion as described above, i.e. the margins, shape and adjacent tissues, and also the location and size. The location and size findings must be consistent on the two examinations, and any differences must be accountable for in terms of changes in breast position or compression.

An accurate, definitive preoperative diagnosis can be routinely established if excellent quality mammography and ultrasound examinations are performed and the results integrated as part of the Triple Test.

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QUALITY CONTROL IN BREAST ULTRASOUND

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Introduction

Quality assurance programmes are an integral part of mammographic studies, but to date the requirement to introduce similar programmes for breast ultrasound has been neglected. The need for quality assurance to ensure that equipment is performing to specification is becoming vital as the use of breast ultrasound becomes generally accepted by the medical community. Furthermore with the significant improvements in image quality in recent years, the interpretive criteria found in ultrasonic images have become more uniform as the quality of the equipment, and consequently of the images, has improved.

With the availability of better images, there is a much greater reliance on the diagnostic accuracy of the ultrasonic examination and therefore a greater need for the clinician to be appropriately trained in this important imaging modality. Accurate interpretation of ultrasonic images not only relies on considerable clinical expertise but also on substantial knowledge of the physical principles of ultrasonic wave propagation through soft tissues.

Training programmes

In a number countries, such as Australia, Japan and the USA, guidelines have been established for ultrasonic breast examination and reporting protocols, the accreditation of formal training programmes has not yet occurred. Attempts in Germany to regulate the use of breast ultrasound, to individuals with appropriate training, have been successful, and courses have been conducted on a regular basis since the mid 1980's.

Breast sessions are incorporated into many scientific meetings at the international level but the principal mechanism for the dissemination of advances in this field has been at
scientific meetings which have been held every two years since 1979 by the International Association for Breast Ultrasound (IABU). Whilst this provides a forum for the latest scientific and clinical results to be presented, these meetings do not satisfy the need for training programmes. In the early 1990's, the International Breast Ultrasound School (IBUS) was be formed. The IBUS organization with a substantial faculty of international breast disease and breast imaging experts provides educational programmes in different countries consisting of didactic presentations and interactive workshop sessions covering aspects of breast disease detection, diagnosis and patient management related to imaging modalities.

**Interpretive criteria**

Ultrasonic images of the breast are remarkably difficult to interpret because of the variations in normality. The varying composition of tissues in each individual results in a wide range of complex patterns which must be analysed in order to determine whether the image clearly typifies a normal tissue distribution or whether the presence of an architectural disturbance indicates an abnormality (1).

The interaction between fat, parenchyma and supportive structures is complex, and varies from one patient to another, even within the same age group. The tissue composition varies with age, and it is important to distinguish normal fat, from the parenchyma, both when surrounding it and when located within it. The heterogeneity of the constituent tissues together with the variability resulting from hormonal influences and involutional changes occurring throughout the woman's life makes the recognition of pathological disturbances in the breast tissue more difficult than in other soft-tissue body organs (2).

Fatty tissues are common in the breast, and are displayed as low-level echo regions. This ultrasonic characteristic is particularly unwelcome as most neoplasms are displayed by similar echo levels. The presence of fatty tissues complicates the recognition of disease, and therefore the interpretation of lesions is based on an aggregate of echo patterns. Physiological factors as well as aging processes modify the constituent tissues, and
therefore change the image appearance over a period of time.

There is no doubt that the grey scale criteria established for breast lesions have been accepted as appropriate descriptors for the interpretation of breast anatomy and pathology. However frequently these criteria are incorrectly applied, and as there is an overlap between benign and malignant features, inexperienced clinicians have difficulty in interpreting the findings with confidence. Interpretation confidence can be greatly increased by thorough analysis of the ultrasonic features, by close correlation between imaging and pathology, and by regular exposure to high-volume breast disease in a clinical setting which provides on-going feedback. With experience, the differentiation between benign and malignant findings can be very accurate, and high resolution ultrasonic imaging can be used to assess patients with breast lesions.

The interpretation of echo patterns is based on the recognition of primary and secondary features associated with lesions. Primary features are an integral part of the lesion. Secondary features are more subtle in nature and are only sometimes displayed, and when present may be distal to the lesion.

At the basic level of interpretation, cystic-solid differentiation is accomplished with a high degree of accuracy, when cysts are greater than 2 to 3 mm in diameter. Many clinicians restrict the use of ultrasonic imaging solely for this purpose, and do not attempt to classify the pathology once it becomes evident that the lesion is solid. However the classification of solid breast lesions greater than 5 mm in diameter can be achieved high-resolution equipment is used and when both primary and secondary features are assessed.

**Reporting protocols**

There have several attempts to standardize reporting protocols and diagnostic criteria but to date no universal agreement has been reached. A standardized reporting format was proposed in 1981 which described the overall appearance of the breast based on the anatomical features, and also analysed any lesions present by its grey scale diagnostic criteria (3). The reporting format was divided into two parts. The first part described the
overall appearance of the breast at nipple level based on the anatomical features. One had to select from five typical patterns representing varying degrees of fat and parenchymal tissues. The second part analysed a lesion by its grey scale diagnostic criteria, which included descriptors for the distortion of architecture, internal echo content, boundaries, posterior details, spatial effect, surrounding tissues, attachments, and skin appearance. The likelihood that the lesion was malignant was expressed as a grouped percentage, ranging from 0 to 100 in five increments. A similar reporting protocol, based on the grey scale diagnostic criteria, was outlined in a poster presented at the Second International Congress on the Ultrasonic Examination of the Breast held in London in 1981 (4).

In 1989, the Japan Society of Ultrasonics in Medicine published a list of diagnostic criteria for differentiating benign and malignant lesions. The format was based on the premise that the criteria had to be simple, easily understood, with common terminology, and comprehensive with regards to disease processes (5). It was reported at the Seventh International Congress on the Ultrasonic Examination of the Breast held in 1991 that the majority of the members of the Japan Society of Ultrasonics in Medicine had accepted the criteria, and found them helpful in the interpretation of breast lesions. The trend in Japan has been towards using ultrasonic breast imaging as a stand alone technique to detect breast cancers under 10 mm in size (4).

With the availability of better scanners and the standardization of imaging diagnostic criteria, the possibility exists to categorise ultrasonic features of breast disease. Acceptance of a standardized reporting protocol is essential if results from different imaging centres are to be compared for quality assurance programmes. In 1990, the Australasian Society for Ultrasound in Medicine recommended an examination and reporting protocol in an attempt to encourage a standardized format.

Performance guidelines for the ultrasonic evaluation of the breast were published in 1993 by the American Institute of Ultrasound in Medicine, and covered equipment, documentation, characterization of masses, and guidance of interventional procedures (6).
Performance measurements

The need to maintain equipment performance is a foremost requirement to ensure consistent high quality imaging (7, 8). A tissue-mimicking phantom, designed for small parts imaging, is appropriate for monitoring system performance, but the composition of phantoms does not adequately duplicate the complex nature of breast tissues. Phantom images show the equipment's ability to display small liquid filled areas and interfaces in the phantom material, but do not reliably predict the scanner's performance with breast lesions where there may only be small differences between the ultrasonic characteristics of normal tissues and pathology.

Regular monitoring of equipment performance should be undertaken on at least a monthly basis to ensure that high quality imaging is maintained. The following parameters can be included in a quality assurance programme: measurement accuracy, relative system sensitivity, relative dynamic range, geometric distortion, and hardcopy performance such as stability of the settings for brightness and contrast. Whilst a small parts tissue-mimicking phantom is appropriate for monitoring these parameters, it is not adequate to determine the scanner's ability in differentiating breast tissues. A realistic assessment can be undertaken by scanning a suitable body part containing various tissue types, such as a limb or a thyroid gland. It is essential that the same part and person are available for monitoring, and that the images and records of the equipment settings are carefully documented for later comparison. The ultrasonic scanner should be serviced on a regular basis according to the recommendations of the manufacturer, and accurate records of the image quality kept for each service period.

Conclusion

Interpretive criteria established for breast lesions have been accepted as appropriate descriptors for the interpretation of breast anatomy and pathology. However frequently these criteria are not strictly applied, and with some overlap in features between benign
and malignant criteria, clinicians have difficulty in interpreting findings with confidence. Diagnostic accuracy can be increased by thorough analysis of the ultrasonic features, and by close correlation of diagnostic results with clinical and pathological findings.

Comprehensive quality assurance programmes need to be implemented in breast ultrasound evaluations in order to properly assess the clinical performance of ultrasonic techniques (9, 10). There have been substantial technological improvements in equipment design, and this has resulted in high quality breast images being more universally available. However, results from different breast imaging centres can only be compared when all performance factors are considered, and it is therefore important to develop ultrasound breast examination guidelines to provide standard ultrasound services (11). Quality assurance programmes need to be developed, and this challenge should be fulfilled in order to confirm and to improve the diagnostic accuracies achieved to date.

References


