TWO-DIMENSIONAL (2D), THREE-DIMENSIONAL (3D) COLOR DOPPLER IMAGING (CDI), AND DOPPLER SPECTRUM OF BREAST MASSES

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**Purpose:** The purpose is to clarify the usefulness of 2D, 3D CDI, and Doppler spectral analysis in diagnosis of breast masses.

**Materials and Methods:** Sixty-one histologically confirmed palpable unilateral breast masses (33 cancers, 26 benign breast masses) and corresponding contralateral breasts were examined by 3D CDI with Doppler spectral analysis using ATL HDI 3000 or 5000. Pulsatility index (PI) and resistive index (RI) were calculated bilaterally.

**Results:** 3D PDI was useful for determination of appropriate FFT sampling points of tumor vessels and corresponding contralateral controls. Compared to the controls, both PI and RI of breast cancers were calculated statistically higher (P <0.001), on the contrary those of benign breast masses were calculated statistically lower (P <0.001). The sensitivity, specificity and accuracy of PI in the diagnosis of breast cancers were 78.8% (26/33), 92.2% (26/28) and 85.2% (52/61) respectively. The sensitivity, specificity and accuracy of the RI were 81.8% (27/33), 82.1% (23/28) and 82.0% (50/61).

**Conclusion:** Comparative Doppler spectral analysis of breast tumor vessels and those in corresponding contralateral normal breast was thought to be useful for the diagnosis of breast tumors. Both PI and RI of breast cancers were statistically higher than those of normal controls, on the contrary those of benign breast masses were statistically lower.
BREAST MASSES: THE EFFECT OF CONTRAST MEDIA ON COLOR OR POWER DOPPLER ULTRASONOGRAM (PRELIMINARY STUDY)

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Purpose: To investigate the value of contrast-enhanced Doppler ultrasonography (US) in the demonstration and characterization of vascularity in breast masses.

Materials and Methods: Nine patients with benign breast mass were prospectively evaluated with color or power Doppler US before and after injection of the contrast agent (SH U 508 A, Levovist). We subjectively analyzed the grade of vascularity, vascular pattern, and the time course of enhancement in benign breast mass. The vascularity was graded into four point scale: 0 (none), 1 (just detectable increase in color Doppler signal intensity), 2 (slight increase in color Doppler signal intensity), and 3 (moderate increase in color Doppler signal intensity). The pattern of vascularity was classified as intratumoral, peritumoral, or mixed.

Results: The Doppler flow signals were detected in 3 benign breast masses at unenhanced color or power doppler US (33%). After injection of Levovist, flow signals were detected in 6 lesions and increased in 3 lesions (100%). At contrast-enhanced color or power Doppler US, three tumors demonstrated grade 1 vascularity, three in grade 2, three in grade 3. The patterns of vascularity were intratumoral in 2, peritumoral in 5, and mixed in 2 cases. The average time to peak enhancement was 1 minute 28 seconds (range, 10 seconds-2 minutes 30 seconds) and enhancement persisted for an average of 1 minute 3 seconds (range, 30 seconds-3 minutes).

Conclusion: Contrast-enhanced power or color Doppler US is superior to unenhanced Doppler US in the demonstration and characterization of vascularity in benign breast masses.
COLOR AND POWER DOPPLER IMAGING OF SOLID BREAST MASSES: SIGNIFICANCE FOR DIFFERENTIATING BETWEEN MALIGNANT AND BENIGN LESIONS

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Purpose: To evaluate the power and color Doppler Ultrasound (PDUS, CDUS) findings of solid breast masses to differentiate between benign and malignant lesions.

Materials and Methods: Total 126 biopsy-proven solid masses (benign 72, malignant 54) were retrospectively evaluated with available PDUS and/or CDUS. We analyzed the location, pattern and shape of the Doppler signals. The location of Doppler signals were classified into central, peripheral and both side. The shape of the signal was divided into four categories: single dot, linear, irregular, branching patterns. The presence of penetrating pattern was separately assessed. We compared between PDUS and CDUS in available cases for which modality showed better and more signals.

Results: Among the 72 benign lesions, 21 cases (29%) showed Doppler signal in both, center in 5 (7%), periphery in 46 (64%). Among the 54 malignant lesions, 36 cases (67%) showed at both, center in 4 (7%), and periphery in 14 (26%). About the shape of the vascular signals, benign and malignant lesions respectively demonstrated linear in 19 (26%) and 9 (17%), irregular in 23 (32%) and 19 (35%), branching in 7 (9%), and 21 (39%), and single dot in 23 (32%) and 5 (9%). The penetrating pattern was noted in 14 (19%) of benign lesions and in 30 (56%) of malignant lesions. Of the 43 cases in which PDUS and CDUS were compared, 21 cases showed better finding at PDUS, PDUS same as CDUS in 17, and CDUS was better than PDUS in 5 cases.

Conclusion: On power or color Doppler US, the most significant findings of predicting malignant breast masses were both central and peripheral location, penetrating pattern, and branching shape. Power Doppler study was more useful than color Doppler study. And overall Doppler sonography is a useful adjunct modality to differentiate between malignant and benign breast masses.
DOPPLER EVALUATION OF AXILLARY LYMPH NODES

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Purpose: To evaluate the efficacy of pulse and colour doppler sonography (CDS) in detecting possible difference in blood flow patterns between malignant and benign axillary lymph nodes.

Materials and Methods: 92 palpable axillary lymph nodes in 67 untreated patients were prospectively evaluated with CDS and doppler flow wave analysis. Histopathologic diagnoses were obtained by sonographically guided fine-needle aspiration biopsy and/or excisional biopsy.

Results: There were 62 malignant lymph nodes (61 were metastatic adenocarcinoma; 48 from breast and 13 from lung; and one was lymphoma) and 30 benign lymph nodes (14 were tuberculous lymphadenitis, two were suppurative granulomatous lymphadenitis, 14 were reactive hyperplasia). Colour flow was seen in 29 of 30 (97%) benign lymph nodes and 52 of 62 (87%) malignant lymph nodes. Both malignant and benign lymph nodes showed predominant peripheral flow distribution. 23 of 81 (29%) colour flow positive nodes showed venous flow alone. Doppler wave analysis was performed in 55 of 92 (60%) nodes. The mean resistive index, mean pulsatility index, mean peak systolic velocity, and mean end diastolic velocity were not useful in differentiating between benign and malignant.

Conclusion: Doppler criteria that have been successfully applied in other lymph node groups cannot be relied upon in axillary nodes.
EVALUATION OF BREAST MASSES AND AXILLARY NODES:
EFFECT WITH MICROBUBBLE ULTRASOUND CONTRAST

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Purpose: To determine the value of US contrast agents in breast masses and accompanying axillary nodes.

Materials and Methods: Forty patients (mean age 56 years) with 42 breast masses and 12 related axillary nodes underwent colour power angiography (CPA) US with and without contrast. Vascular features were semiquantitatively assessed with a grading system of 0-5. Transit time of contrast for all masses was also observed. Pre and post contrast appearances were compared with pathology.

Results: In the breast: pathology revealed 26 carcinomas and 16 benign lesions. Significant increase in vessel number and tortuosity was seen in both malignant (mean score 1.5 to 3.1 and 0.7 to 1.5 respectively, p<0.0001) and benign (mean score 1.3 to 2.4 and 0.3 to 0.9 respectively, p<0.05) breast masses after contrast injection. No difference in onset and duration of contrast enhancement of benign and malignant lesions was demonstrated. Using published criteria for improvement of diagnosis using contrast agents led to six false positive diagnoses and reduction of specificity to 43.8%. In the axilla: US guided FNA confirmed 8 malignant and 4 benign nodes. After contrast significant increase in vessel number and tortuosity was seen. Grading was more than, or equal to, the primary tumor in 5 of 8 malignant lymph nodes. All 4 benign nodes showed a vessel number grade less than the primary tumor after contrast.

Conclusion: Microbubble contrast CPA US increases visualization of vessel number and tortuosity in both benign and malignant lesions and increases sensitivity but not specificity. This is not in agreement with published data. The increase in vessel grading of malignant nodes was equal to or greater than the primary tumor in 62.5% raising interesting possibilities for the value of contrast agents in breast mass diagnosis.
THE EFFECT OF MICROBUBBLE CONTRAST AGENT (SH A 508 U, LEVOVIST®) ON DIFFERENTIATING MALIGNANCY FROM BENIGN BREAST DISEASES

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Purpose: To evaluate the effects of a galactose/palmitic acid based US microbubble contrast agent SH A 508 U Levovist to differentiate malignancy from benign breast diseases.

Materials and Methods: Twenty-five breast lesions in 24 patients aged 31-62 years underwent Doppler US examination before and after intravenous injection of Levovist. Pathologically-proven 25 lesions were 18 infiltrating ductal carcinomas (17 patients) and 7 benign diseases (6 fibroadenomas, and 1 fibrocystic disease). The contrast enhancement were introduced by injection of 8.5 ml of a 300mg/dl suspension which was made of 1.5gm package of Levovist® (Schering, Berlin, Germany) mixed with 7 ml of distilled water into the right antecubital vein at flow rate of 1-2 ml/sec. Doppler studies were performed using HDI 3000 (ATL, Bothell, USA) with 7-10 MHz transducer. The effects of contrast agents were analysed (1) to evaluate the changes in peak systolic velocity and resistive index, (2) to analyze flow patterns under criteria of 0-3 (no flow, marginal flow, penetrating flow, branching flow), (3) to compare onset time, amount of increased Doppler signals, and evaluation of the transit time of contrast enhancement before and after injection of contrast agents in breast lesions.

Results: The peak systolic velocities and resistive indices significantly increased after injection of Levovist® in breast cancers (average 34.06 cm/sec and 1.51), comparing to the benign lesions (average 18.42 cm/sec and 1.07). After injection of contrast agent, the flow patterns showed branching patterns in infiltrating ductal carcinoma (89%). The flow patterns in benign diseases varied from pattern 0 to 1 (14.3%), and from pattern 1 to 3 (28.6%). The number of vessels after Levovist significantly increased (> 3 vessels) in malignancy (66.7%) than in benign disease (14.3%). Peak systolic velocity became to elevate earlier within 30 seconds and within 60 seconds in both benign diseases (85.7%/14.3%) and breast cancers (44.4%/16.7%) after injection of contrast media. The transit time of contrast enhancement were much longer (>9 mininutes, 61.1%) and multiphasic in elevation curves (94.4%) in breast cancer than in benign diseases (>9 minute, 14.3%).

Conclusion: After injection of Levovist, carcinomas and benign lesions behave differently in degree, onset, and duration of Doppler US enhacement. Therefore, we think it is possible to differentiate malignancy from benignity by using Levovist, althought individual variablity may be present limitating the diagnostic value.