# E18. Role of colour Doppler ultrasound in breast imaging

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## Introduction

Breast cancer has the tendency to produce angiogenetic factors that influence vessel growth into the tumour. As a consequence of this, neovascularisation can be found inside the tumour and in the peri-tumoural tissue. Investigations evaluating the quantity of blood flow, the vascularisation pattern inside and outside of the tumour and the imaging information related to contrast enhancers have been published [1–5]. Vascular assessment aims to assist with differentiation between benign and malignant breast tumours and to provide information about the degree of neovascularisation, which correlates with the biological behaviour of the tumour. Two-dimensional (2D) and three-dimensional (3D) ultrasound techniques to analyse colour-coded blood flow are discussed.

## Power-Doppler, colour-Doppler, high-definition flow

The vascularisation of a breast lesion can be investigated using 2D and 3D techniques with power-Doppler (amplitude-based colour-Doppler sonography) and frequency-based colour-Doppler sonography, which presents coded colours related to the median frequency shift combined with the option of spectral-Doppler analysis. Power-Doppler shows the energy of the Doppler signal in colours and has the advantage over colour-Doppler ultrasound of not being angle-dependent. To study the detailed vascular structure of a breast lesion, blood flow rates of less than 1 cm/s have to be detected, combined with an optimised signal-to-noise ratio. High-definition flow (HD-Flow) is a colour-Doppler technique that offers a slow flow detection comparable to power-Doppler and additionally provides information about the direction of blood flow.

The studies of Kutschker *et al.* [1] on spectral-Doppler analysis of stage T1 and T2 breast cancers showed statistically significant lower peak systolic flow ($V_{max}$) and higher resistive index values (RI) compared with stage T3 and T4 breast cancers. The problem with using spectral-Doppler parameters to differentiate benign from malignant breast lesions is that stage T1 and T2 breast cancers show almost the same spectral-Doppler values as benign breast lesions.

The colour-coded methods have the ability to present the neovascularisation of a carcinoma with an irregular vascular pattern, arterio-venous shunts and missing vessel-autoregulation in contrast to normal breast-tissue vessels. This is the background for many studies with 2D ultrasound and computer-assisted quantitative colour-Doppler analysis aiming at a differentiation between malignant and benign breast lesions [2–5]. The advantage of the quantitative colour assessment is the reduction in the influence of the examiner on the evaluation of the colour information. The mean colour value (MCV: mean colour value of all colour values) and the colour pixel density (CPD: percentage of colour pixels within the defined region of interest [ROI]) were evaluated by S. Huber and colleagues [3,4]. Studies on the effects of a microbubble contrast agent in combination with computer-assisted quantitative assessment of colour-Doppler ultrasound showed the CPD peak in malignant tumours to be higher and faster than in benign breast lesions [4].

The morphological pattern of tumour vessels and tumour feeding vessels has been studied by 2D and 3D ultrasound. In 1997 Madjar and Jellins [6] described the contrast enhancement flow from the periphery to the centre of malignant and benign tumours. In that study the carcinomas showed this pattern more pronouncedly, with malignant neovascularisation revealed as having a distinct radiating pattern and a vascular corona, equivalent to the growth zone of the tumour, visible in the echo-dense rim seen on B-mode ultrasound. Stuhrmann and colleagues studied the vascularisation of breast tumours and found that the morphological pattern and the course of the vessels were the parameters that offered the best differentiation between benign and malignant breast lesions (sensitivity 95%, specificity 83%) [7]. They described three types: type 1, the avascular type; type 2, the benign type with a monomorphic vascular pattern and only a little vascularisation; and type 3, the malignant type with an irregular arrangement of the vessel distribution, different vessel size and a radiary vessel access to the lesion.

Analysis of the three-dimensional vascular architecture is an approach for 3D HD-Flow, 3D power-Doppler and 3D colour-Doppler studies. 3D power-Doppler imaging

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provides the analysis of blood flow and three-dimensional vascularisation patterns of the entire tumorous lesion without the limitation of scanning only two-dimensional planes, including the potential problem that the most representative slice might not be scanned. 3D HD-Flow additionally shows the blood-flow direction in the three-dimensional vascular architecture [8,9]. Glass body rendering is a special transparency mode, which makes the greyscale data transparent and displays the colour data of 3D HD-Flow, 3D Power-Doppler and 3D colour-Doppler in a surface mode. This mode offers the basis for a detailed study of the three-dimensional vascular supply of the lesion and of the surrounding breast-tissue structures. In combination with glass body rendering, the vascular architecture in relationship to the tumour extent and the surrounding breast tissue can be investigated. Suppressing the greyscale parameters a three-dimensional angiogram will be obtained.

3D power-Doppler volume information offers an effective tool to evaluate the colour histogram and the spatial distribution of the vessels inside and outside the malignant or benign tumour. 3D reconstructions of the colour volume data are suitable for studying the three-dimensional vessel distribution and the potential irregularities in vessel shape [8,9]. The colour histogram provides information about the vascularisation index (VI), the flow index (FI) and the vascularisation-flow index (VFI) inside a user-defined volume of interest (VOI). VI gives information in percent (%) about the amount of colour values (vessels) in that volume of interest; it is calculated by dividing the colour values by the total voxels minus the background voxels of selected VOI. The dimensionless flow index (FI) measures the mean blood-flow intensity; it ranges from 0 to 100. FI is calculated as the ratio of weighted colour values (weighted by their amplitudes) to the number of the colour values. The vascularisation-flow index (VFI) gives combined information about vascularisation and mean blood-flow intensity. VFI is also dimensionless and ranges from 0 to 100. It is calculated by dividing the weighted colour values (weighted by their amplitudes) by the total voxels minus the background voxels.

## Conclusion

3D power-Doppler combined with the representation of three-dimensional vessel architecture, VoCal, colour histogram and the additional option of intravenous contrast enhancers are important tools for further studies of tumour neoangiogenesis.

Thus, the progression of 2D and 3D ultrasound in presenting the vascular supply and vascular architecture of a breast lesion makes these techniques useful diagnostic imaging tools to help differentiate benign from malignant breast lesions.

## References

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