

Computer-Assisted Dynamic Breast Thermography

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•Dynamic breast thermography provides new functional information, complementary to conventional steady state thermographic findings. In a standardized cooling procedure the skin temperature of the breasts is decreased by 2.5 C to 3 C by means of two fans. During the subsequent recovery phase a sequence of 20 frontal thermograms is recorded. The quantitative analysis is mainly based on criteria similar to those most commonly used for the interpretation of plate thermograms. The classification of the sequences is carried out by a discriminant analysis. On a test group of 162 symptomatic patients with negative clinical and radiologic evidence, and 51 patients with proven breast cancer, 72.5 per cent of the patients with breast cancer, and 80 per cent of the patients with negative clinical findings, were classified correctly, according to quantitative dynamic thermography alone. When dynamic thermography was applied supplementary to the static examination, 40 per cent of the patients without tumors, but with suspicious steady state thermograms, showed normal thermodynamic behavior. The result implies a reduction of the thermal "false positive rate" of about 40 per cent.

Microprocessor assisted infrared thermography systems produce digital thermograms with high spatial and temporal resolution.^{1,2} Steady state temperature distributions and thermodynamic processes during and after an artificial cooling procedure of the tissue, can be recorded by thermograms, or by a time series of thermograms. Quantitative analysis allows the extensive thermal and thermodynamic information to be reduced to a set of parameters which are specific for certain diseases.

A procedure for the quantitative analysis of steady state thermograms of the female breast was developed earlier at the Institute of Biomedical Engineering.^{1,4} It has been evaluated clinically with respect to the diagnosis and early recognition of breast cancer in extensive studies in collaboration with the University Hospitals of Basle and Zurich. The analysis criteria are based on the surface temperature distributions of the two breasts. The corresponding parameters are sensitive to thermal asymmetry, local

hyperthermia, and unusual temperature differences between selected reference areas. On the basis of these parameters a statistical discriminant analysis led to a classification scheme with five thermographic classes (TH1 . . . TH5). Each class corresponds to the patients with a certain thermographic risk for breast cancer; completely normal thermograms are classified TH1 while TH5 indicates a strong suspicion for breast cancer. The result extends the basis for diagnosis or prognosis and for the identification of patients with a high risk for developing breast cancer. In retrospective studies the classification procedure led to positive thermograms for about 80 per cent of patients with histologically confirmed breast cancer, while 80 per cent of patients with negative clinical and radiologic findings showed negative thermographic findings. The classification scheme is now used for a prospective classification of patients.

The rate of positive thermographic findings for patients without proven carcinomas is often called the "false positive rate," although it is well known that a positive thermogram in many cases may represent a high risk factor for breast cancer.^{5,6} Systematic long term supervision is suggested for the corresponding women, but this may cause a certain psychological stress. In other cases, positive thermograms are related to normal, rather than pathologic anatomic or physiologic irregularities of local perfusion. In these cases, new and complementary information often can be achieved from dynamic thermographic examinations.⁸ Negative dynamic thermographic findings indicate a lower carcinoma risk factor. Thus, for the corresponding patients, normal screening might be sufficient.

The following paper describes the recording of thermodynamic behavior of the breast surface after artificially induced cooling of the tissue with an air stream. During the rewarming phase a sequence of digital thermograms is acquired. Based on quantitative parameters describing the thermodynamics of the breast surface and a classification scheme which was worked out similar to that of static thermograms, we performed a comparison between the two methods. The paper also will discuss how many patients without diagnosed carcinoma with positive steady state thermograms show negative thermodynamic results.

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