Microwave Thermography in the Detection of Breast Cancer

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Microwave thermography, a method of sensing subcutaneous temperatures, was used in a breast cancer detection study of about 5,000 female patients. The data were taken at wavelengths of 9.1 and 23 cm. Microwave thermography at 23 cm has true-positive and true-negative detection rates of 0.8 and 0.6, respectively, comparable to those of infrared thermography (0.7) and inferior to those of xeromammography (0.9). However, a potential advantage results if microwave and infrared thermography are used together for screening, and if mammography is used only for follow-up on those patients who were positive on either the microwave or the infrared thermograms. It is then possible to obtain true-positive and true-negative detection rates of 0.9 and 0.9, respectively, while only half the number of patients need be subjected to x-rays.

Microwave thermography is the detection of microwave radiation from the human body and may be most clearly envisioned as the microwave analog of infrared thermography. Whereas infrared thermography uses wavelengths of 10 μm (typical), microwave thermography makes use of much longer wavelengths, typically 1–20 cm; this leads to important and fundamental differences between the two techniques. These have been described in detail in our previous publications [1–4] and can be summarized as follows:

1. Microwave radiation is capable of penetrating human tissue and therefore the emission provides information related to subcutaneous conditions within the body. Infrared radiation is incapable of such penetration and therefore relates to conditions primarily on the surface.

2. The intensity of microwave emission is linearly proportional to the temperature of the emitter. Therefore a measurement of the emission may be easily related to the temperature of the emitter. Infrared intensity measurements may also be related to temperature but in a less direct (and nonlinear) manner.

3. Microwave emission, being at a longer wavelength than infrared, gives correspondingly coarser spatial resolution. Typical spatial resolution is on the order of 1 cm for microwaves, whereas infrared thermography usually yields spatial resolutions of the order of 1 mm.

The first two items above imply that microwave thermography provides information on internal body temperatures. The depth of penetration, and hence the depth from which microwave radiation may escape from the body, depends on the wavelength, the dielectric properties of the tissue, and, most importantly, on the water content of the tissue. Typical values of the depth of penetration are given in figure 1.

Microwave thermography is a noninvasive, passive technique, like infrared thermography, and does not subject the patient to radiation hazards, pain, physical stress, or discomfort. It may be repeated as often as desired without harmful effects.

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