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Diagnostic model for local temporal thermal change at the skin of the breast during extended application of diagnostic ultrasound

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A biophysical model is derived to account for the temporal thermal change at the skin of the breast as a result of ultrasound stimulation at the suspect lesion for seven minutes, with responses recorded using an infrared camera. Twenty-two patients were studied. The observed temporal responses for malignant cases have a different pattern from those of the benign cases studied and a mathematical model is used to investigate the controlling parameters. A new method is used to estimate the coefficients of the resulting difference equation which allows more useful diagnostic parameters to be computed than the corresponding continuous bioheat equation. The model is used to fit the experimental data. The results suggest that this method might be a rapid and noninvasive aid for distinguishing between benign and malignant breast tumours.

Keywords: breast cancer; ultrasound; skin temperature; temporal response; feedback control model; diagnostic parameters.

1. Introduction

Mammography is considered the most useful screening technique and currently the only reliable means of detecting breast cancer before a mass can be palpated in the breast. However, even the most experienced radiologist will be able to visualize and identify only approximately 90% of the malignant lesions present, resulting in a significant false negative rate. In addition, because of the nonspecificity of the mammographic appearance of many malignant lesions, false positives can also occur. It is also accepted that mammography is less discriminatory for detecting breast cancer in premenopausal women in whom the breast parenchyma is often more dense resulting in a decrease in radiographic contrast. Ultrasonography is an ideal complement to mammography because the ultrasound characteristics of malignant lesions are often highlighted in dense parenchyma, and cystic lesions can be usually differentiated from solid ones. Breast ultrasound used in this way is often useful in reducing the number of biopsies which might be generated by equivocal clinical or mammographic lesions. However, it will fail to detect small *in situ* breast cancers where there is no structural abnormality of the breast parenchyma and, as pointed out by Croll (1984), ultrasonography may fail to demonstrate a mass lesion in a fatty breast because the echoes from such tumours are similar in amplitude to those recorded from the fatty tissue.