

Thermographic Detection of Breast Cancer

Kenneth R. Foster, *Dept. of Bioengineering, University of Pennsylvania*

Biomedical engineers of a certain age will remember the photograph in the 1978 edition of Webster's *Medical Instrumentation* [1] of a woman having her breasts examined for cancer by infrared thermography—a quick and painless procedure that could save her life (Fig. 1). Neither this photo nor any mention of infrared detection of cancer are found in later editions of this text. The rise and fall of infrared detection of breast cancer is an interesting story, with an obvious lesson for present-day biomedical engineers.

Detection of Breast Cancer

Breast cancer afflicts one American woman in 11 sometime during her life, and about 45,000 American women die of the disease every year. Ductal carcinomas, by far the most common form of the disease, arise in the lining of milk ducts. In early stages of growth, a tumor can remain in the duct as carcinoma in situ, doubling in size every four months or so. Once it grows larger than about 2 mm, it escapes into surrounding tissue. The tumor eventually invades lymph nodes near the axilla. At some point, it begins to shed cells that invade the rest of the body, leading to systemic disease. Early detection of breast cancer can benefit the patient by allowing treatment that will avoid disfiguring surgery and greatly improving her prospects for long-term survival.

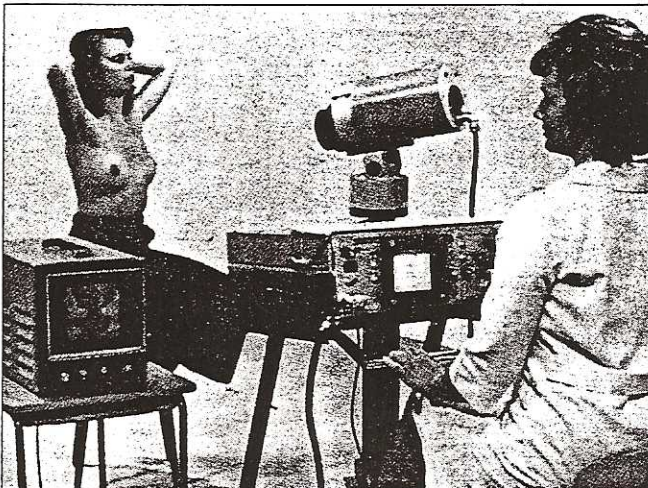
Doctors have imaged the female breast using X-rays since the early years of this century. But mammography as a mass screening tool dates to the late 1960s, following a large-scale clinical test by the Health Insurance Plan of New York, which showed that early detection of breast cancer by mammograms could reduce mortality from the disease [2]. (Indeed, breast cancer is presently the only disease for which radiologic methods are used for mass screening.)

X-ray mammography is convenient and inexpensive. However, it has important disadvantages, including the exposure of the subject to ionizing radiation. (In the mid-1970s, a high resolution film X-ray of the breast would result in an exposure of 40-90 mGy [3], which led some authorities to worry whether routine screening of women in their 40s, in whom breast cancer is rare, might induce more cancers than it detected.) Mammography is also uncomfortable, since the breast has to be compressed between flat surfaces to improve image quality. Adequate images are difficult to obtain from radiologically dense breasts (with little fat) or in women with breast implants.

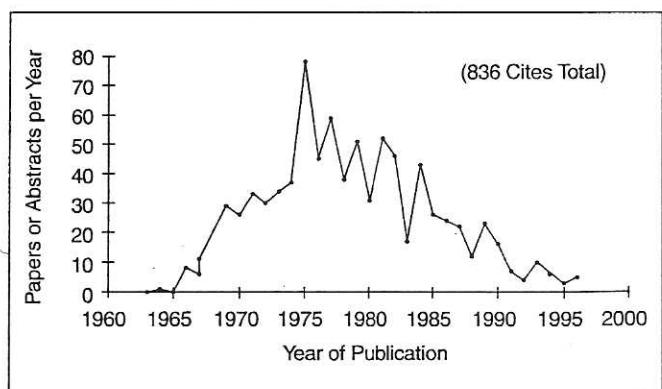
Given these problems, the idea of thermal detection of breast cancer had obvious appeal. The method is based on the fact that the temperature of the skin over a tumor in the breast is frequently higher (by as much as 2-3 degrees) than over normal tissue, perhaps because of higher metabolic activity or increased vascularity of the tumor compared to normal breast tissue. Thermal imaging can be done using an infrared camera costing about \$50,000, or by placing an inexpensive liquid-crystal film against the breast. The other breast serves as a built-in control.

The first report of the use of temperature measurements to diagnose breast cancer was apparently published in 1956 [4]. Responding to awakening interest in mammography, a flurry of papers appeared in medical journals around the world in 1966 on the detection or diagnosis of breast cancer by thermal imaging [5-10]. One pilot study reported that thermography and X-ray mammography had comparable results in detecting tumors [11].

Interest in the technique built rapidly (Fig. 2), among both researchers and among practicing physicians. Several manufacturers introduced thermography units to the market. The procedure



1. Woman being imaged by infrared thermography. From Webster, *Medical Instrumentation* (1978) [Reproduced with permission of FLIR Systems, Ltd.].



2. Number of papers per year identified by a Medline search on the keywords "thermography and breast." Only a fraction of these papers are original research reports; many are reviews or commentaries. However, the figure indicates the rise and fall in the level of interest among physicians in thermal detection of breast cancer.