# APPLICATION OF SECOND GENERATION INFRARED IMAGING WITH COMPUTERIZED IMAGE ANALYSIS TO BREAST CANCER RISK ASSESSMENT

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## ABSTRACT

Infrared imaging of the breast for breast cancer risk assessment with a second generation focal plane staring array system was found to produce images superior to a first generation scanning system. The second generation system had greater thermal sensitivity, more elements in the image and greater dynamic range, which resulted in a greater ability to demonstrate asymmetric heat patterns in the breasts of women being screened for breast cancer. The improved imaging of the second generation infrared system allowed more objective and quantitative visual analysis, compared to the very subjective qualitative results of the first generation infrared system. The greater sensitivity and resolution of the digitized images of the second generation infrared system also allowed image analysis of total breasts, breast quadrants and hot spots to produce mean, standard deviation, median, minimum and maximum temperatures.

KEY WORDS: Thermography, Infrared Imaging, Breast Cancer, Risk Assessment, Diagnosis

## INTRODUCTION

Early studies of infrared (IR) imaging of the breast concentrated on its ability to diagnose breast cancer. Mammography and IR imaging, commonly called thermography in medicine, were compared for diagnostic ability during the Breast Cancer Detection and Demonstration Projects (USA) between 1973 and 1981, but IR imaging was discontinued after only a few years and no risk assessment or prognostic information was collected. Beginning in 1980 studies supporting the use of IR imaging in breast cancer risk assessment [1, 2, 3] and prognosis [3, 4] began to appear. The present study was designed to determine whether the improvements in IR technology that have been incorporated into the second generation focal plane indium antimonide detector IR imaging systems can improve the images used in breast cancer risk assessment.

## METHODS

Patients at The Elliott Mastology Center (Baton Rouge, LA), who were being screened with mammography for breast cancer, underwent IR imaging of their breasts as part of their breast cancer risk assessment. During the study normal and high risk patients had IR images of their breasts taken with an Inframetrics scanning mercury cadmium telluride detector IR imaging system (right lateral, left lateral and frontal views) and recorded as hard copy photographic images (a color frontal isotherm view and three black and white views: frontal, left lateral and right lateral). For comparison 3 additional breast views (frontal, right lateral and left lateral) were recorded with an Amber focal plane indium antimonide staring array IR imaging system. IR images of 220 patients from both the scanning and focal plane systems were digitized and stored on computer hard disk, thus creating a digitized IR image database for later image analysis.

## RESULTS

The focal plane array system produced much higher quality images than the scanning system. However the focal plane system often placed a great proportion of the patient's IR heat pattern beyond the upper limit of the heat range being recorded and thus blacked out the patient (black is hot in medical applications). The blacking out occurred because the averaging window for determining the temperature range had too much cool background when imaging thin patients. The first decision made was to try to quantitate the six individual asymmetric abnormalities that were present in the focal plane images and then to create an IR index by adding together the individual scores for each abnormality (small hot spot, score=1; large hot spot, score=2; global heat, score=3; vascular heat, score=1,2,3; areolar heat, score=1; edge heat, score=1). The focal plane images had IR indexes that ranged from 0 to 8 but the highest index computed was five. Previously, scanning IR images were abnormal if any of the six asymmetric abnormalities were present, and images that only had a borderline IR asymmetry were called slightly abnormal (3 levels of results: normal, slightly abnormal, abnormal).

The IR indexes derived from the second generation focal plane imaging results were compared to the levels of abnormality from the scanning results on the patients being screened for breast cancer. Chi-square analysis for independence showed that the two methods produced results that were strongly associated (p=.0001). The most interesting result was an increase in the sensitivity for asymmetric heat patterns with the focal plane system, as 50.5% (111 of 220) of the patients without breast cancer had abnormal IR images, whereas only 32.7% (72 of 220) of the patients had asymmetric heat patterns with the scanning system. Analysis of the six asymmetric abnormalities individually showed that most of the increase in sensitivity could be attributed to a significant (p=.0038) increase in vascular asymmetry from 43 of 218 patients with the scanning system to 70 of 220 with the focal plane system.

Next the distribution of the IR index was compared to the levels of abnormality from the scanning images to determine if the increase in sensitivity of the second generation technology would create small subsets with higher IR indexes that could be used to refine risk assessment. When an IR index of 1 is considered to be so insignificant that a patient's risk of getting breast cancer is not increased and 2 is considered to only slightly increase risk, then 14.1% (31 of 220) of the patients being screened for breast cancer would be categorized as high risk individuals. On the other hand 37 of 220 patients had abnormal IR images with the scanning system and this would mean that 16.8% of the screened patients would be at high risk.

Three known risk factors (family history of breast cancer, previous estrogen hormone therapy and previous breast biopsy) were compared to the IR results from the scanning and focal plane systems. None of these risk factors were found to correlate with the IR imaging results and therefore IR imaging results were found to be an independent risk factor in breast cancer. The physician also assigned patients being screened for breast cancer into normal and high risk categories by subjectively integrating family history, mastopathy, previous use of estrogen hormones and previous breast biopsy. The results of this physician integrated risk assessment was also not related to the IR imaging results.

The final part of the study was an attempt to apply image processing and computer vision techniques to produce objective measures of asymmetric heat patterns present in second generation IR images employed in breast cancer risk assessment. Preliminary results showed that comparative pixel statistics (mean, standard deviation, median, minimum, maximum temperatures) could be computed for complete breasts, quadrants of the breast and hot spots.

## DISCUSSION

The improved image of the second generation IR imaging system was due to the greater thermal sensitivity, greater number of elements and greater dynamic range of the focal plane array imager. The one major drawback encountered in this study was blacking out of patients and this will be corrected in the future by adjusting the center of the temperature range (set at either 7.5 or 10°C) of the focal plane imager to optimally take in the temperature range of the patients. This procedure for temperature focusing has been routinely used with scanning IR imagers and has worked very well in breast cancer risk assessment.

The proportion of patients at increased risk of breast cancer is probably still a little high with the second generation IR system, but the strength of the IR index is not in the overall proportion of patients that are at increased risk but with its ability to create different groups of patients at increased risk by adjusting the weight of the different abnormalities being inputted into the index. Future studies will be able to address the independent value of the 6 abnormalities and to create an index where the value of each abnormality will be appropriately weighted. This process of weighing the value of independent variables is not possible with the 3 level subjective analysis used with the scanning system.

In this study the lack of association between IR imaging results and known risk factors in patients being screened for breast cancer confirms that IR results are independent of known risk factors. Therefore, in light of the evidence [1, 2, 3] showing a strong association of asymmetric IR abnormalities of the breasts with a high risk of getting breast cancer, it can be concluded that abnormal IR images are a significant independent risk factor for breast cancer.

The comparative measurements resulting from the initial image analysis need to be done on a large database of focal plane images to determine their utility. Hopefully by removing the subjectivity of the present analysis and by providing additional information to the physician there will be an improvement in risk assessment by IR imaging. Models for the analysis of the breast IR images need to be developed that reduce perspective distortions that are inherent to imaging of 3 dimensional shapes and also to overcome the lack of ideal body symmetry due both to the natural asymmetry of the human body and also the spatial orientation of the imager to the subject. Finally the whole analysis must be automated, as highly interactive analysis is not conducive to the typical practice of medicine.

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