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Original Research Article

A comparative study of mammography, sonography and infrared thermography in detection of cancer in breast

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ABSTRACT

Background: Breast cancer has emerged as the commonest cancer in Indian women. In a large population country like India we need a rapid, economical, and accurate investigation to diagnose breast cancer in its earlier stage. The objective of this study was to compare the effectiveness of mammography, sonography and infrared thermography in detection of breast cancer.
Methods: Patients presenting to the surgical OPD with suspicious breast lump were evaluated by infrared thermography, sonography and mammography followed by biopsy of the breast lump. Results of the all 3 above radiological modalities were compared with the histopathological biopsy for the presence of the cancer. The study was done between 1st December 2012 to 31st August 2014 in Sassoon General Hospitals attached to B. J. Government Medical College, Pune. We compared the performance of all diagnostic methods individually and in combination using the results from all patients. Statistical analysis was performed for all variables with fisher's exact test.
Results: Out of 50 patients, 31 patients had malignant breast lesions and 19 patients had benign lesions on biopsy. The mammography showed higher diagnostic accuracy and specificity than ultrasonography and thermography. As an individual modality the sensitivity of the sonography was higher than mammography and thermography.
Conclusions: Sonography is found to have higher sensitivity than mammography and infrared thermography but it is less specific than mammography. Mammography is found to be more specific (89.47%) than sonography and infrared thermography.

Keywords: Sonography, Mammography, Infrared thermography

INTRODUCTION

Breast cancer is the most common cancer in women (about 30% of all cancers). One woman out of 8 develops breast cancer during their lifetime. Breast cancer has emerged as the commonest cancer in urban Indian women.[1] Worldwide mortality due to breast cancer in the year of 2012 is 5.22 lakh and in India it is 70,000 for the same year. According to WHO, for the year 2012, an estimated 70218 women died in India due to breast cancer, more than any other country in the world (second: China - 47984 deaths and third: US - 43909 deaths).[2] So, it will be a cancer burden to Indians, for which we need to identify the breast cancer patients in their earliest stage and should treat them accordingly to reduce the mortality from breast cancer. We need to focus the health resources of India towards rural part where most of the cases are not diagnosed in its earlier stage. The most important reason being lack of awareness about breast cancer and screening of the same. More than 50% patients of breast cancer present in stage III or IV. Almost all Indian breast

cancer patients self-detect their disease at a stage when it presents with a palpable lump or even at a stage when it has resulted in secondary changes such as local skin or chest wall changes or distant metastases.[3]

While the majority of breast cancer patients in western countries are post-menopausal and in their sixties and seventies, the picture is quite different in India with premenopausal patients constituting about 50% of all patients (SGPGIMS Lucknow data).[3] The average age of breast cancer patients has been reported to be 40-50 years in various population-based studies done in different parts of the country.[4] Hence an investigation modality is needed to detect breast cancer in early stage.

At present the most common methods for detecting the breast diseases are mammography, ultrasonography and biopsy. However, these techniques only provide information on the anatomical structures which depends primarily on structural distinction and anatomical variation of the tumour from surrounding breast tissue lacking functional information.[5] At present, the main screening tests include mammography and ultrasonography.

Mammography is the most commonly used imaging examination for the screening of breast cancer. However, the rate of false negative rates can reach up to 30% and expose patients to ionizing radiation.[6] In addition, mammography is less effective in younger women and those with denser breast tissue.[7]

Ultrasonography is primarily used for differentiating between cystic and solid properties of breast lesions identified by mammography. It can examine dense breast tissue, and guide aspiration biopsy and preoperative localization. Because of the time needed to perform an examination, the need for appropriate operator training and other constraints, ultrasonography alone is not suitable as a screening method for breast cancer. Indeed, ultrasound and mammography may miss many cases where the tumour is <0.5cm in size.

In a search for other imaging techniques thermography has emerged as a potential method to aid in detection of cancer in breast. The technical principle behind far infrared thermography is relatively vigorous intracellular glucose metabolism in malignant lesions, which causes greater angiogenesis, producing more thermal energy than normal tissues.[8] Advances in technology and computer modelling have led to renewed interest in using thermography as a screening tool for breast cancer.[6,8-10] Advantages of thermography include simple and fast test administration, and quantitative computer software result analysis; it requires less advanced technical operator training relative to other screening methods and testing is relatively inexpensive.[6,7] Thus, far-infrared thermography is a workable imaging technique for breast cancer patients.

METHODS

The study being a clinical and prospective was conducted after obtaining detailed history, general physical examination and systemic examination. The study was done between 1st December 2012 and 31st August 2014 at Sassoon General Hospitals attached to the institution B. J. Govt. Medical College, Pune. Our study included all cases presenting to the surgical OPD with suspicious breast lump who were admitted and evaluated by infrared thermography, sonography and mammography, followed by biopsy of the breast lump next day.

Inclusion criteria

Inclusion criteria were patients of age >40 years who presented with suspicious breast lump.

Exclusion criteria

Exclusion criteria were patients of age less than 40 years, previous history of breast surgery for breast cancer, patients with diagnosed breast cancer who is on treatment like chemotherapy or radiotherapy.

Total number of cases were 50. All patients underwent infrared thermography followed by, breast sonography and mammography. Core biopsy of the lump done next day. The data regarding patient particulars, diagnosis, investigations and outcome were collected in a case recording form. All these data were transformed to a master chart and subjected to statistical methods to compare the 3 radiological investigations in prediction of cancer detection. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of all the three investigation systems were assessed. Interpretation of the various diagnostic procedures was compared with the histological examination.

Procedure

Thermography

All objects with a temperature above absolute zero emit infrared radiation from their surface. The Stefan-Boltzmann law gives the relationship between the infrared energy and temperature. Emissivity of human skin in carcinoma breast is high and measurements of infrared radiation emitted by skin can be directly converted to temperature.[11]

Patients were instructed to not to smoke, consume alcohol, perform strenuous exercise, or apply lotion to the breast within 4 hours before the examination. Infrared thermography was deferred if the patient had undergone a fine needle aspiration (FNA) within 2 days or core biopsy within 2 weeks before the examination, because these may affect the results of far-infrared thermography. It is very important that proper protocols are used when

performing breast thermograms. These include adequate cooling down procedures prior to imaging (for 10 to 15 minutes), no windows or open doors, exclusion of outside light, controlled climate and humidity, no air blowing directly on the patient and maintained room temperature of 18°C to 22°C range. Patients are asked to undress to the waist in a private dressing room to allow the surface of the breasts to cool to room temperature (18°C to 22°C) taking about 15 minutes. For the scan, the patient is asked to stand about 10 feet in front of the camera with her arms raised over her head while three views of the breast (anterior and two lateral views) are taken. The next step in the process is a 'cold challenge' where the patient is asked to place both hands in cold water at 10°C for one minute; then these same three images are retaken.[12,13] The breasts exhibit thermal patterns that are captured by the infrared camera. It is these thermal captured image patterns that are interpreted by a trained thermographer. According to the magnitude of temperature gradient all images divided into 2 classes: normal (ΔT ≤3) and positive for malignancy (ΔT >3). Figure (1 and 2) shows the images of thermography from normal patients and breast cancer patients respectively.

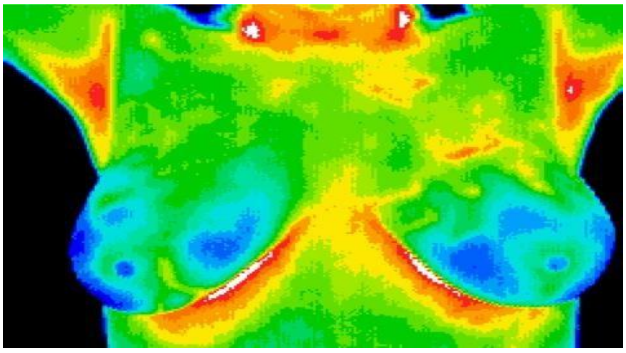

Figure 1: Thermograph showing normal breast (ΔT ≤3).

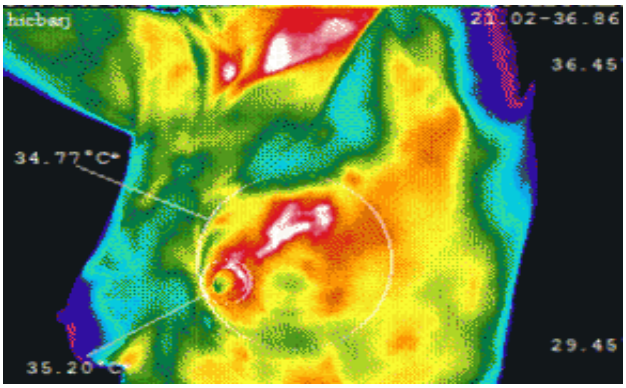

Figure 2: Thermograph showing the left breast cancer (ΔT >3).

Ultrasonography

Doppler ultrasonography was performed by professional radiologist using a colour doppler ultrasound with a 5-12 MHz high frequency probe. Scanning was performed in a standard manner. ACR-BIRADS (American college of radiology - breast imaging reporting and data system) grading of sonography was used. Grade 1 to grade 3 were taken as benign lesions and grade 4 and 5 were taken as positive for malignancy. Figure 3, shows ultrasound image of breast cancer (BIRADS - 4) with microcalcification.

Figure 3: Ultrasound breast showing malignant mass with irregular sharp stellate contour and a cluster of calcifications at 9 o'clock.

Mammography

Digital mammography was performed and mediolateral oblique (MLO) views and craniocaudal (CC) views were obtained in accordance with the current technological requirements and standards of the American college of radiology (ACR) for breast X-ray examination. ACR-BIRADS (American college of radiology - breast imaging reporting and data system) grading of mammography was used. Grade 1 to grade 3 were taken as benign lesions and grade 4 and 5 were taken as positive for malignancy. Figure 4, shows positioning of the patient in mammogram. Figure 5, shows the microcalcification in mammography.

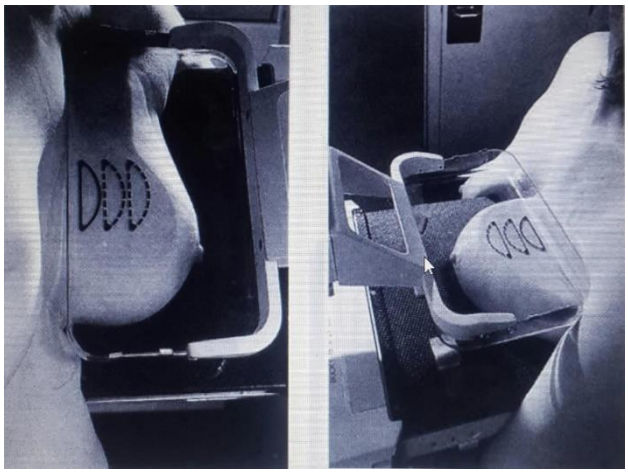

Figure 4: (a) Positioning for the lateral oblique and (b) cranio-caudal view of mammogram.

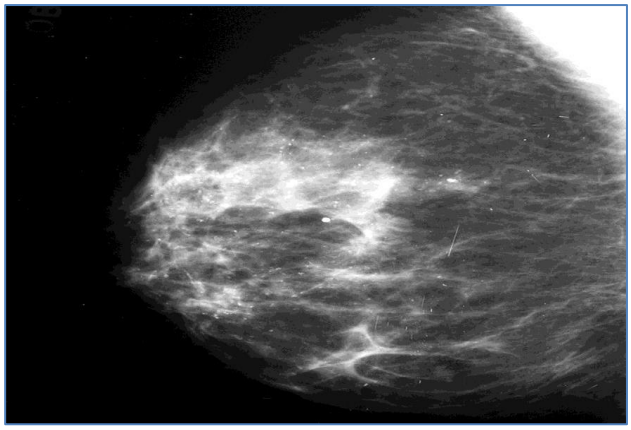

Figure 5: Mammography image of patient with microcalcification.

All patients underwent core biopsy of the lump next day and samples were sent for histopathological examination. This study was approved by the ethical committee of our institution, and all patients provided their written informed consent.

Statistical analysis

Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were evaluated. We compared the performance of all diagnostic methods individually and in combination using the results from all patients. The chi-square test or fisher's exact test were used for group comparisons. All analyses were performed with SPSS version 13.0 statistical software; a value of $p<0.05$ was considered to indicate statistical significance. Out of 50 patients, 31 patients were found to have malignant breast lesions and rest of the 19 patients were found to have benign lesions on biopsy. Table 1, shows statistical analysis of the parameters of the individual investigation modality and in combination with each other (n=50).

RESULTS

Out of 50 patients, 31 patients were found to have malignant breast lesions and rest of the 19 patients were found to have benign lesions. Table 2, showing distribution of patients with benign and malignant lesions on biopsy. The diagnostic accuracy of mammography (84%) was higher than ultrasonography (82%) and thermography (72%), but there was no significant difference between the accuracy of ultrasonography and thermography.

As an individual modality the sensitivity of the sonography (83.87%) was higher than that of mammography (80.65%) and thermography (74.17%). The specificity of mammography (89.47%) is higher than sonography (78.95%) and thermography (68.42%).

Table 1: Comparison of sensitivity, specificity, PPV, NPV and accuracy of mammography, ultrasonography and thermography and also combination of the investigations (n=50).

Variables	Pathological examination		Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %	P value (in relation to HPR)
	Malignant	Benign						
Mammography								
Malignant	25	2	80.65	89.47	92.59	73.91	84.00	<0.001
Benign	6	17						
Sonography								
Malignant	26	4	83.87	78.95	86.67	75.00	82.00	<0.001
Benign	5	15						
Thermography								
Malignant	23	6	74.17	68.42	79.31	61.90	72.00	<0.004
Benign	8	13						
Mammography and sonography								
Malignant	29	4	93.55	78.95	87.88	88.24	88.00	<0.001
Benign	2	15						
Mammography and thermography								
Malignant	28	6	90.32	68.32	82.35	81.25	82.00	<0.001
Benign	3	13						
Sonography and thermography								
Malignant	28	6	90.32	68.42	82.35	81.25	82.00	<0.001
Benign	3	13						
All three tests								
Malignant	29	6	93.55	68.42	82.86	86.67	84.00	<0.001
Benign	2	13						

*HPR- histopathological report.

When used as conjunction the combination of the mammography and sonography showed highest sensitivity compared to other combinations. In our study when sonography was used as an adjunct to mammography, sensitivity raised to 93.55% but there was a drop in specificity to 78.95% and found to be the most accurate combination for the detection of carcinoma breast. Diagnostic accuracy was 88% p value <0.001 which is significant. When thermography was used in adjunct to mammography or sonography found to have the same results with increase in sensitivity to 90.32% and drop in specificity to 68.42%. Both combinations not found to be superior to mammography and sonography combination.

When all three modalities were used in combinations there is no improvement in sensitivity or diagnostic accuracy when compared to mammography and sonography combination.

Table 2: Distribution of patients with benign and malignant lesions on biopsy.

Lesions	No. of patients	Percentage
Benign	19	38
Malignant	31	62
Total	50	100

DISCUSSION

As an individual modality sonography is found to have higher sensitivity than mammography and infrared thermography but it is less specific than mammography. Malur et al studied sonography in 439 patients and found a respective sensitivity, specificity, PPV, and NPV of 89.1%, 79.1%, 65.7%, and 90.9% which is similar to our study.[14] Table 3, shows comparison of our study results of sonography with other studies.

Table 3: Comparison of our study results of sonography with other studies.

Parameters studies	N	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Our study	50	83.87	78.95	86.67	75.00	82.00
Malur and Wurdinger et al[14]	439	89.1	79.1	65.7	90.9	83.4
Buchberger et al[15]	60	79	50			
Tan et al[16]	326	82	84	60	94	84

Table 4: Comparison of our study results of mammography with other studies.

Parameters studies	N	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Our study	50	80.65	89.47	92.59	73.91	84.00
Yaoa, Weia and lia et al[18]	2036	78.3	98	93.3	93.63	93.56
Malur and Wurdinger et al[14]	439	83.7	68.5	67.8	84.1	77.1
Buchberger et al[15]	60	82	96			

Table 5: Comparison of our study results of thermography with other studies.

Parameters studies	N	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Our study	50	74.19	68.42	79.31	61.90	72.00
Yaoa, Weia and Lia et al[18]	2036	84.4	94.0	81.32	95.12	91.7
Wang et al[19]	276	72.4	76.6	81.3	66.4	
Rassiwala and Mathur et al[21]	1008	97.6	99.17	83.67	99.89	

In our study mammography is found to be more specific (89.47%) than sonography and infrared thermography. American college of preventive medicine found that of mammography sensitivity range from 75% to 90% with specificity from 90% to 95%. The positive predictive value of mammography for breast cancer ranges between 60% to 80% in women age 50-69.[17] Table 4, shows comparison of our study results of mammography with other studies.

In our study thermography showed sensitivity of 74.19%, specificity of 68.42%, positive predictive value 79.31%, negative predictive value of 61.9% with diagnostic accuracy of 72%. (p-value is 0.004 which is significant). Wang et al, studied five thermography signs by age adjusted multivariate logistic regression models in 276 women who received thermography excisional biopsy and at the most optimal cut off they reported a sensitivity, specificity, PPV, and NPV of 72.4%, 76.6%, 81.3%, and 66.4%, respectively.[19] However, Kontos et al studied thermography in 63 patients and found a respective

sensitivity, specificity, PPV, and NPV of 25%, 85%, 24%, and 86%.[20] Table 5 shows comparison of our study results of thermography with other studies.

When sonography was used as an adjunct to mammography, sensitivity raised to 93.55% but there was a drop in specificity to 78.95%. and found to be the most accurate combination for the detection of carcinoma breast. In 2002, Kolb et al, published a landmark article that showed improved sensitivity (97% versus 74%), when sonography was used adjunctively with mammography compared with mammography alone.[22] He also observed an increased in positive rates with the use of ultrasound as an adjunct to mammography.

In recently published results of an ACRIN trial that included 2637 women with heterogeneously dense breast in at least one quadrant observed that the diagnostic accuracy improved from 0.78 to 0.91 when ultrasound was adjunctively used with mammography.[23]

When thermography was used in adjunct to mammography or sonography found to have the same results with increase in sensitivity and drop in specificity. Both combinations not found to be superior to mammography and sonography combination. In a 2003 study conducted by Parisky et al assessing the effectiveness of infrared imaging to evaluate mammographically suspicious lesions found thermography to have a 97% sensitivity and positive predictive value of 25%.[24] The study was a 4 years clinical trial that evaluated 875 suspicious mammographic lesions for which breast biopsy had been recommended.

When all three modalities were used in combinations there is no improvement in sensitivity or diagnostic accuracy when compared to mammography and sonography combination.

The advantage of mammography is it increases the detection of small abnormal tissue growths confined to milk ducts in the breast, called ductal carcinoma in situ. Improves a surgeon's ability to detect small cancer and usually have no side effects in the diagnostic range.

CONCLUSION

As an individual modality sonography is found to have higher sensitivity than mammography and infrared thermography but it is less specific than mammography. Mammography is found to be more specific (89.47%) than sonography and infrared thermography.

For cancer breast detection we have got a number of investigations in options with varying level of diagnostic accuracy. In the past 30 years there have been numerous studies that have demonstrated thermography to have the ability to detect breast abnormalities that other screening methods may not have identified. In a country like India in light of developments in computer technology and the maturation of the thermographic industry additional research is required to confirm diagnostic accuracy of the investigation. To know much more about the best investigation of choice for diagnosis of breast cancer more such comparative studies and trials are required in multicentre.

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