Thermal Imaging for Breast Cancer Detection: A Controversy

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Abstract

Breast cancer is proving to be second leading cause of death in females worldwide. It occurs when cells in the breast lose normal growth control and results in metastasis or malignant tumor that spreads throughout the body. Breast cancer accounts for 10% of all women cancers and approximately 22% of all cancer deaths worldwide. Several well established imaging modalities used to screen breast cancer include CBE, mammography, ultrasound, MRI & CT scan. Mammography has been treated as the gold standards for detection of breast cancer but still suffers from limited sensitivity, specificity and several other limitations as a screening tool. Ultrasound and CBE are used as adjunctive tools in screening women with dense breast in coordination with mammography. The limitations of MRI are that it is not good at detection of ductal carcinoma in situ, is slow, expensive and fails to show all calcifications. However all these modalities suffer from one or more common disadvantages of radiation exposure, breast compression, only structural imaging, breast density, age and BRCA1/2 mutations. Hence imaging future is demanding a screening technique which can detect malignancy before any anatomical changes takes place within the body noninvasively and can be applied frequently. It has been reported that cancerous breast areas exhibit abnormal thermal behavior. Thermal imaging involves detection of physiological changes like hyperthermia and hypervascularity due to neoangiogenesis to supply abundant requirements of nutrients to the tumor. The objective of this paper is to represent controversies related to thermal imaging & to represent this imaging modality as the future gold standard for early detection of the breast cancer if carried out in controlled environment by considering in detail, clinical history with modern imaging facilities.

Keywords: Breast cancer; Imaging modalities; Thermal imaging.; Infrared imaging; Malignancy.

1. Introduction.

Breast cancer is a kind of cancer that develops from breast cells. It is the most common invasive cancer and is proving to be leading cause of deaths in women worldwide. It occurs when cells in the breast lose normal growth control and invade neighboring tissues [1]. The malignant tumor can spread to other part of body also called as metastasis. Tumor grown in the lobules is known as lobular carcinoma and one developed from the duct is called as ductal carcinoma [2]. High degree of specificity and sensitivity is required in disease diagnosis because false positive result may lead to surgical removal of breast.

The imaging modalities traditionally used by radiologist in the detection of the breast cancer include mammography, MRI, CT-scan & CBE, ultrasound as adjunctive tools. More recently thermography, a relatively new screening technique based on temperature a tumor may produced, is proving exceptional in early detection of breast cancer [3]. One thing which should be very clear is that neither of these modalities detects but demonstrates abnormalities indicating the presence of cancer as well as host of other breast conditions. Only laboratory confirmation of abnormal cell morphology will be considered as the final detection of cancer [4].

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In this paper, our focus is on controversies related to the imaging modality capable of monitoring physiological changes within the body noninvasively without exposure to carcinogenic radiation and can be applied repeatedly for prognosis [2]. Another important feature of this screening technique is that it depends on physiological changes instead of anatomical and hence is able to diagnose breast cancer at least ten years in advance i.e. before tumor formation [1] [4]. As there is a thumb rule, early detection means life in breast cancer, early detection of abnormalities will help to reduce mortality rate. The imaging modality incorporating all above features, approved by US FDA on 29 JAN, 1982 is Breast Thermography, also called infrared thermal imaging [5].

2. Screening Techniques for Breast Cancer

This section presents a brief review and distinction between the various screening techniques applied for evaluating breast abnormalities.

2.1 Clinical Breast Examination

Clinical breast and self breast examinations are manual that are performed by the physicians or by the patient himself. The physicians are supposed to examine both breasts of patient for lumps and other abnormalities such as inverted nipple, nipple discharge [2]. It is reported that well performed CBE and SBE detects at least 50% of asymptomatic cancers. The sensitivity of CBE alone is 21% comparable to the sensitivity of mammography which is 78%, but together, it is 81% for breast cancer detection [6].

2.2 Mammography

Since the early 1960s, X-ray mammography is the gold standard and most common imaging modality used for early detection of breast cancer [6]. Mammography uses low dose amplitude X-rays for screening of the breast. Cancerous masses, calcification appears brighter in mammograms [5] [7]. Mammography is based on anatomical structure of breast for diagnostic of tumor; a beam of x-ray traverses the breast and creates a projected image on a film [8]. The sensitivity is in between 75% to 90% with positive predictive value of only 25%. However, sensitivity and specificity of mammography are limited and may be influenced by the factors such as age, breast density and family history [6]. Mammography is good for detection of ductal carcinoma in situ and calcifications. Mammography is cost effective tool but with several challenges and risks like breast density, discomfort due to breast compression, tumor encapsulation rupture risk, ionizing radiation exposure, age and BRCA1/2 mutations [5] [9] [10].

2.3 Breast Ultrasound

This screening technique helps physician to decide whether a lump is a solid mass or a fluid filled cyst [2]. In this technique ultrasound transducer transmits high frequency waves in to the breast tissues & collects reflected waves to display 2D image. Breast ultrasound is used as an adjunctive tool to mammography in the evaluating palpable and impalpable abnormalities [1]. This technique is exceptionally useful in screening mammographically dense breast and abnormality characterization in mammograms [11]. The accuracy of breast ultrasound depends on instrumentation quality, physician's skill set towards procedure and ability to interpret screens. The only limitation is that the sensitivity of this technique declines in detecting impalpable tumors [11] [12].

2.4 MRI

MRI uses radio waves and strong magnetic fields for breast imaging. This method involves injecting of contrast enhancing dye-like material into the patient’s bloodstream to monitor the way in which the material is taken up and drain out by the tumor [12]. This imaging technique helps physician to determine the extent of cancer i.e. metastasis and response to chemotherapy before surgery [2]. Several studies have shown that MRI can detect malignancies that are not interpreted in mammography. Also numerous studies evolved that malignant tissues have elevated levels of choline containing compounds. These compounds may serve as non invasive markers in cancer detection. State-of-the-art imaging modalities derived from this segment namely MRI, MRS, nuclear imaging and optical imaging are finding their applications in precise diagnosis of breast malignancies and
prognosis. The limitations of this imaging modality are false positive results, unable to diagnose ductal carcinoma, time consuming procedure (30 min. to 60 min.) and five times costly than x-ray mammography [1][12].

2.5 PET

PET, Positron emission tomography is a nuclear medicine imaging modality produces 3D images and providing information about chemical function inside organs, tissues [1][13]. This modality detects pair of gamma rays emitted indirectly by short lived radioactive tracer isotope injected into the body on a biologically active molecule. The most common molecule used is fluorodeoxyglucose and there is a waiting period for molecules to get concentrated in organ of interest before placing patient in the imaging scanner [8]. The malignant tumor is evaluated by increased glucose metabolism compared with normal cells in PET scan. PET produces distinct contrast between cancerous and normal cells. However, PET yields poor resolution, it is expensive and involves radiation exposure [1][13].

2.6 CT-scan

CT scan uses x-ray to capture breast images and by using different algorithms 3D images are built, which provides information on anatomical issues. During scan iodinated contrast enhancing media is intravenously injected to increase the contrast of image captured. It is showed that CT perfusion can prove effective tool for studying enlarged axillary lymph nodes in patient with malignancy [1][14]. Diagnosis with CT is possible only after appreciable size taken by the formation of tumor. A hybrid imaging technique combining CT-scan and PET is also proving to be useful in staging the degree of metastasis cancers [1].

2.7 Breast Thermography

Breast thermography started during 1956, is a promising imaging modality as it is able to warn breast cancer ten years in advance [1][5][7]. Clinical thermography is the recording of heat distribution in order to form thermograms of the body surface temperature by sensing the IR radiation emitted by the human skin noninvasively using IR imager [10]. Breast thermography as a diagnostic tool for tumor detection is based on the fact that cancerous and precancerous tissues have high metabolic rate resulting in neoangeogenesis, supplying nutrients to tumor. As a consequence, the temperature of that area is higher compared to normal breast tissues temperature [1]. Thermography is a distinct imaging modality as it focuses on physiological investigation like hyperthermia, hypervascularity, thermoregulatory dysfunctions and not on structural or anatomical issues [7]. This makes thermography a unique screening technique for early detection of malignancies i.e. even before tumor takes its physical shape. The average size of tumor detected on a mammogram is 1.66 cm, while in thermography is 1.28 cm [15]. Breast cancer detection using thermograms is to analyze temperature asymmetry i.e. abnormality between right and left breast [1][11]. It can also be used as immediate and short term prognosis tool providing both qualitative and quantitative analysis of area in question [9]. It is mentioned that the chances of discovering breast malignancies increases by 40% in case of a patients who has consistent abnormal thermograms [16]. Followings are the important futuristic advantages of breast thermography over traditional methods and proving to be unique in several aspects.

- Completely non-invasive; done without ionizing carcinogenic radiation, compression, sensor contact or needles [1][7][10].
- Ability to examine dense breast tissues in young women, even children and men is possible [1].
- No painful procedures and maintaining complete privacy. No compression so no risk of rupturing tumor encapsulation [6].
- Detection of inflammatory breast cancer. Identifies fibrocystic tissues and distinction between benignity versus malignancy.
- Effective for all age groups and with all types of breast tissues like young, dense pregnant, breastfeeding, pre and post menopausal, large, enhance with implants and when on hormone replacement therapy.
- Thermograms can be taken frequently for prognosis i.e. to monitor effectiveness of treatment [1].

However, there are challenges with this modality which need to be resolve for becoming future
promising modality for early detection of breast cancer. Following are the few:

- Analysis and interpretation totally depend on analyst, resulting more false positive and false negative results [1].
- Not able to localize tumor accurately that can be surgically biopsied [1] [6].
- Breast thermography fails to detect slow growing and biologically non-aggressive tumors as it shows minor neoangogenesis [6] [16].
- Sensitivity and specificity of breast thermography is completely decided by clinical instrumentation, image processing software, controlled imaging environment and finally interpretation quotient of radiologist [1].

3. Discussion on controversy

Breast cancer detection using various imaging modalities itself is a controversial subject. As an example, there is yet a debate between experts and professional bodies about when routine mammography should be done. Some experts suggest age of 40 while others insist on 50 years [2]. About thermography, it is used to extract functional information on thermal and vascular conditions of the breast tissues. This helps an assessment of risk factor for developing or existing tumor. After being started in 1956, it was discarded some years later because of lack of high resolution thermal images, limited sensitivity - specificity, high rate of false positive and false negative results [4]. But with recent developments in highly sensitive IR cameras, computer intervention in image processing algorithms and elimination of inter-observer variability, all the issues behind the root causes of controversies are resolving [3]. From studies at CTA laboratories, it is clear that thermography provides significant data for interpreting risk of developing breast malignancy [12]. Appropriate trainings, equipments, regulations, standard protocols, anecdotal versus scientific evidences are the key factors for the universal acceptance of breast thermography [4].

4. Conclusion

Early detection of breast malignancy is a big challenge today in front of medical engineering. Role of imaging modalities is of vital importance in assisting the physicians for diagnosis, characterization of lesion, staging, selection and monitoring the effectiveness of treatment. However, no single modality is proving to be 100% accurate & hence hybridization is the best solution to encounter results.

Breast thermography, an exceptionally promising adjunctive diagnostic methodology is indicative of abnormal breast physiology and can’t be ignored longer. As a result of reappraisal, imaging centers are loaded with the state-of-the art IR imager, computer aided diagnosis techniques and continuous evolution of models for early detection of breast tumor. Progressive use and maturation of this screening may supersede traditional techniques due to its unique advantages. Also the awareness about the facts like no dangerous radiations resulting new cancer genesis, non-invasive, no pain, wide spectrum patient’s coverage, cost effectiveness, repeatability and many more is making breast thermography unstoppable.

References


