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BREAST CANCER DETECTION USING BREAST MRI: A REVIEW

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ABSTRACT
Breast cancer is the most common type of cancer in women and the second leading cause of cancer related deaths, next to lung cancer. Although men can also get breast cancer, cases of male breast cancer account for less than .05% of all breast cancer cases are diagnosed. If eight women live to the age of 85, at least one of them will develop breast cancer in her lifetime. Two thirds of women diagnosed with breast cancer are over the age of 50, and the majority of the remaining women diagnosed with breast cancer are between the ages of 39 and 40. Breast density measurement is an important aspect in breast cancer diagnosis. There are several methods are there for breast density measurement such as density measurement using mammogram, ultrasound and MRI. This paper gives the overview of these three methods advantage and disadvantage.

Keywords: *Breast anatomy, Parenchyma patterns, Mammographic density measurement, Ultra sound density measurement, density measurement using MRI*

I. INTRODUCTION

While the incidence and mortality rates of breast cancer vary internationally, currently it is the most commonly diagnosed cancer among women in most parts of the world .breast cancer accounts for the second cause of cancer deaths despite the significant improvement in survival rates since the mid-80s. Currently the 5-year survival rate is 87% likely as a result of advances in treatment and breast cancer screening. Breast cancer develops through multiple stages and the reason why some tumors eventually become invasive and metastatic and some of them remain non-invasive pre cancers is still under investigation. Current research has looked at breast composition in an attempt to determine significant risk factors that could be associated with the development of cancer. Breast density, a representation of the amount of breast dense parenchyma present in the breast, has been identified as a significant risk factor and an important biomarker influencing the later risk of breast cancer. Ongoing epidemiological studies conducted by Boyd et al. are looking at quantitative assessment of breast density in young women using MRI.

A. Breast anatomy

The breast is a modified skin gland that lies on top of the musculature that encases the chest wall. The breast is not completely separated from these muscles, in fact only a layer of adipose tissue and connective fascia separate the breast from the pectoral muscle.

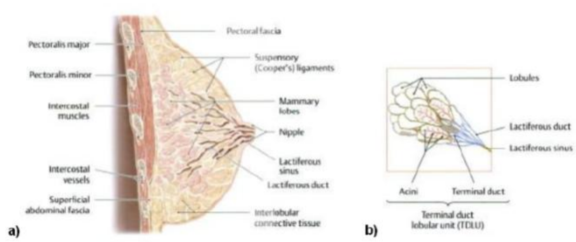

fig1: Anatomy of the breast

The breast is composed of three major tissue types: glandular tissue (parenchyma), fibrous stroma and fatty tissue. The stroma is composed of connective tissue, ligaments, blood vessels, lymphatic, lymph nodes, and nerves and its main function is to provide support and to nurture the breast. The glandular tissue is organized in a ductal system. Current literature agrees that the parenchyma of the breast consists of about 10 to 20 lobes, each of which has a lactiferous major duct that opens on the nipple through a little antechamber called the lactiferous sinus. Starting at the nipple, the ductal system splits up in branches that reach the back of the breast. At the end of each branch are the lobules that produce milk.

B. Breast Development And Cancer Susceptibility

Breast tissue unlike other tissues in the body is very sensitive to develop cancer. The basis of this difference is the fact that cells in the breast mostly divide and differentiate after birth and therefore are at a higher risk of acquiring mutations during development. Cells in the breast of a newborn are very immature and remain this way until the onset of puberty, when cells start to develop in response to sexual hormones. At this point, stem cells in the breast being differentiate into duct cells or lobular cells. Research has found that some stem cells remain undifferentiated perhaps to replenish injured cells. These findings have motivated a new hypothesis focusing on these cells as origins of cancer. On a different line of thought, some researchers have studied the factors that contribute to breast cancer susceptibility. Pike showed that breast tissue exposure to carcinogens has the greatest susceptibility to cause abnormal mutations around the time of puberty but decreases with the first pregnancy and continues to reduce further in pre menopausal and menopausal periods. Pike's work also explained how the area under the exposure-age curve could be used to describe the increasing incidence of breast cancer with age. The incidence of breast cancer with age has a distinctive curve. Below the age of 50 years, the incidence is about the same in widely different geographical locations. However, around the age of menopause and after menopause (> 50 years) the incidence is lower for non-western countries than for western countries. The high incidence rates in white women in north America and in several western European countries can be explained with the high prevalence of well known reproductive factors associated with an increased risk, such as early menarche, late age at first full-term pregnancy, fewer pregnancies and use postmenopausal hormone therapy, but also non-reproductive factors such as increased detection with mammography screening.

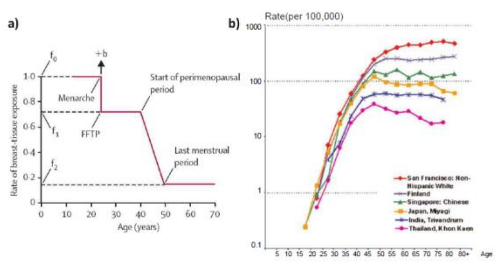

Fig2: Pike's model of breast tissue exposure.

The pattern of premenopausal cancer have attracted the attention of several researchers. While postmenopausal cancer is more likely to be explained by reproductive risk factors, premenopausal risk factors, prognosis of the disease and tumor biology have been found to be somehow different in women below 40 years, suggesting that cancer in this age subgroup is a different entity.

II. MAMMOGRAPHIC DENSITY MEASUREMENT

A. What is mammographic density?

Figure3 illustrates six mammographic images of the breast. It is seen that the breast has a wide range of appearance on mammography, associated with differences in tissue composition. Radio graphically the breast consists mainly of two component tissues: fibro glandular tissue and fat. Fibro glandular tissue is a mixture of fibrous connective tissue (the stroma) and the functional (or glandular) epithelial cells that line the ducts of the breast (the parenchyma). Fat has a lower X-ray attenuation coefficient than fibro glandular tissue and, therefore, is more transparent to X-rays. Thus, regions of fat appear darker on a radiograph of the breast. Regions of brightness associated with fibro glandular tissue are referred to as 'mammographic density'. From the pattern of brightness in a mammographic image, the relative prevalence of these tissues in the breast can be inferred.

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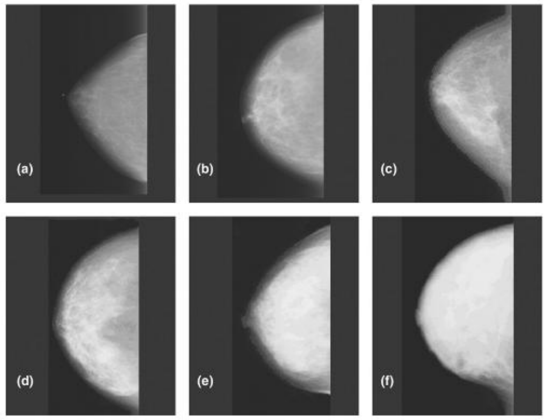

Fig3: A six-category system for classifying mammographic density

B. Parenchymal patterns and density

In 1976, John Wolfe, a radiologist who specialized in mammography, first proposed that there was a strong association between the "parenchymal patterns" seen in the mammogram and the risk that a women would later develop breast cancer. He defined four patterns (later known as Wolfe grades) to characterize the breast. The N pattern, which represented a fatty radiolucent breast, connoted the lowest breast cancer risk. The P1 and P2 patterns indicated progressively greater levels of prominence of fibrous tissue surrounding the ducts and correspondingly higher risk, while the DY pattern indicated the highest risk with a breast that contained dense sheets of fibro glandular tissue. The association of the Wolfe patterns with risk of breast cancer has been reviewed by Saftlas and Szklo and by Goodwin and Boyd, who concluded that there is a two- to three-fold increase in risk between the N and DY patterns. Because it appears that it is the increasing prevalence of fibro glandular tissue in the breast that gives rise to the increased risk, most subsequent work in this field has attempted to measure mammographic density explicitly.

C. Breast imaging reporting and data system

Currently, a widely used density classification scheme is the one associated with the Breast Imaging Reporting and Data System (BIRADS) for reporting findings on mammography. This density system has four categories: BIRADS-1 indicates a predominantly fatty breast; BIRADS-2 scattered fibro glandular densities; BIRADS-3 a breast that is hetero-generously dense; and BIRADS-4, the highest level, an extremely dense breast that could obscure a lesion. This qualitative system was not developed to quantify risk, but to allow an interpreting radiologist to indicate the level of concern that a cancer in the breast might be missed on mammography due to masking by dense tissue. It is well known that the sensitivity of mammography is decreased in the dense breast and a high BIRADS score tells a referring physician who is concerned about breast cancer that other tests less affected by density, such as ultrasound or magnetic resonance imaging (MRI), might be warranted. More recently, in an attempt to make the BIRADS density system more quantitative, it has been recommended that mammograms be classified into four density categories with upper bounds of 24%, 49%, 74% and 100%

III. MEASURING BREAST DENSITY WITH ULTRASOUND DENSITY MEASUREMENT

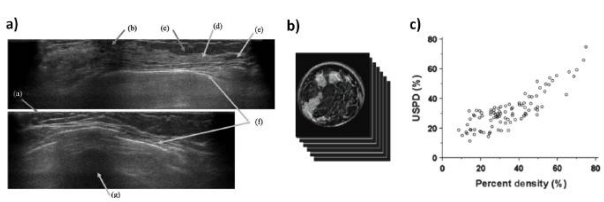

Fig4: Breast density measurement by ultrasound.

Ultrasound imaging is relatively cheap, highly available and does not use ionizing radiation. Ultrasound can measure breast density knowing that the speed at which sound travels through a medium is related to tissue density and elasticity. One method for measuring percent density by ultrasound tomography consists on segmenting areas of fast sound speed from each speed tomogram, integrating these areas over the entire volume, and dividing by whole-breast volume to derive the volumetric ultrasound percent density (USPD). The authors reported a Spearman correlation coefficient of 0.75. Other methods for measuring density use automated whole breast ultrasound (ABUS) to acquire the volume of the whole breast and then, by manually excluding non-breast regions it is possible to derive the total fibroglandular area. The percent density is calculated based on the ratio of the fibroglandular area over the whole breast area for all of the acquired 2D slices.

IV. MEASURING BREAST DENSITY WITH MRI

MRI is a very versatile imaging modality that provides a 3D view of the breast for assessment of volumetric breast density without exposure to ionizing radiation. Based solely on image analysis one can measure breast density using MRI. T1-weighted imaging can be used to distinguish between fat tissue and dense tissue. The contrast mechanism in MRI is dictated by tissue relaxation. Particularly, T1 relaxation describes the recovery of the longitudinal magnetization due to the thermal interactions between hydrogen nuclei (the spins) and large macromolecules within the tissue microenvironment (the lattice).Due to differences in tissue composition, different tissues have different T1 values. In the breast, T1 values are shorter for fat (about 250 msat 1.5T) than for fibroglandular tissues (about 700 ms at 1.5T). As a consequence, T1 effects tend to cause fat tissue to have higher signal (appear brighter) than fibroglandular tissue.

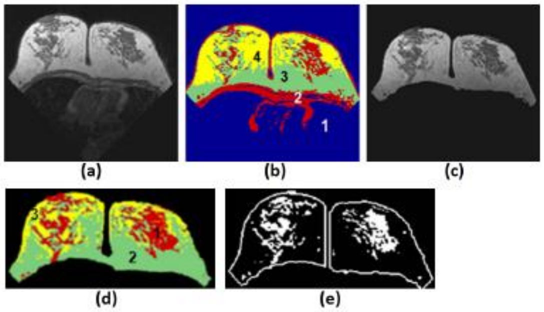

Fig5: Breast density measurement using T1-weighted imaging.

Breast density measurement is an important aspect in breast cancer diagnosis as dense tissue has been related to the risk of breast cancer development. The purpose of this study is to develop a method to automatically compute breast density in breast MRI. The framework is a combination of image processing techniques to segment breast and fibroglandular tissue. Breast MRI is a technique employed for

1) Screening for breast cancer in high risk patients
2) Evaluation of tumor

Segmentation of the different structures visible in a breast MRI is needed to perform an automatic analysis of such images. Some examples of applications in breast MRI which require an initial segmentation step are multimodal breast image registration, computer aided analysis of dynamic contrast enhanced MRI, and breast density assessment. Related to the latter, breast density has been identified as an important risk factor for developing breast cancer, with risk being four times larger in women with a breast density higher than 75%, compared to those with little or no density In general, two steps are required to obtain 3-D breast density measurement from MRI: Breast segmentation and fibroglandular tissue segmentation. The segmentation of the breast is initially performed to exclude other tissue that does not belong to the breast, such as pectoral muscle. The separation of the breast from the body is a difficult task. Complicating factors are the large shape variations of pectoral muscles across different patients and the similarity between intensity distributions of the MRI signal in muscle and fibroglandular tissues. Other issues are caused by the lack of agreement on the anatomical extent of the breast. Because no automated segmentation method was available, manual intervention has been mostly required in the literature. In some studies, the definition of the breast-body interface was made by manually defining a straight line. Other studies combined edge detection filters and manual outlining to delineate the breast volume, Nie.et al. used an approach for breast volume segmentation that also requires some manual intervention when the chest wall is connected to fibroglandular tissue.

A general overview of the process to estimate the breast density segmentation is explained bellow. Three preprocessing steps are there first, image in homogeneities are corrected Second, the sternum is detected, which is used as an important landmark in different parts. Third, intensities of the MR images are normalized to compensate for inter patient signal intensity variability. The segmentation starts separating the body from the breast. The body consists of lungs, heart, pectoral muscle, thoracic area, and fat outside the base of the breast. The breast is connected to the pectoral muscle and is composed by fatty and dense tissues. Finally, the breast volume is defined and the dense tissue is delineated.

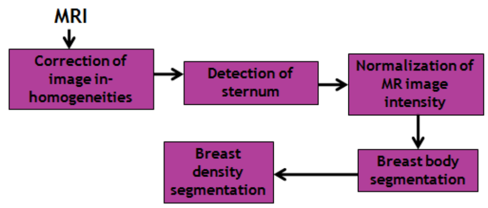

Fig6: block diagram of breast density measurement using breast MRI

V. CONCLUSION

There are several methods for breast density measurement such as density measurement using mammogram, ultrasound and MRI. It is seen that the breast has a wide range of appearance on mammography, associated with differences in tissue composition. Radio graphically the breast consists mainly of two component tissues: fibroglandular tissue and fat. Fibroglandular tissue is a mixture of fibrous connective tissue (the stroma) and the functional (or glandular) epithelial cells that line the ducts of the breast (the parenchyma). Fat has a lower X-ray attenuation coefficient than fibroglandular tissue and, therefore, is more transparent to X-rays. Thus, regions of fat appear darker on a radiograph of the breast. Regions of brightness associated with fibroglandular tissue are referred to as 'mammographic density'. From the pattern of brightness in a mammographic image, but it is having the limitation such as mammographic densities may vary with different projections, level and angle of compression, and scanner calibration. X-ray mammography is a 2D imaging modality that offers only a projection image rather than a volumetric equivalent of the three-dimensional breast. Ultrasound imaging is relatively cheap, highly available and does not use ionizing radiation. Ultrasound can measure breast density knowing that the speed at which sound travels through a medium is related to tissue density and elasticity. But sometimes it is unable to determine whether or not a mass is malignant, and a biopsy will be recommended many cancers cannot be detected via an ultrasound. MRI is a very versatile imaging modality that provides a 3D view of the breast for assessment of volumetric breast density without exposure to ionizing radiation

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