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Various Technologies for Detection of Breast Cancer

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Abstract: The meaning of breast is either of the two soft, protruding organs on the upper front of a woman's body which secrete milk after childbirth. In scientific term breast is referred as mammary gland. The different technologies which are used to view the human body in order to diagnose, monitor or treat medical conditions are referred to as Medical Imaging. Specific technologies are used to investigate and analyse different information about the explicit area of the body being studied or treated, related to possible disease, injury or the helpful for medical treatment. There are several medical imaging technologies that are used nowadays like X-ray, Ultrasonography (USG), Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) etc. In breast cancer diagnosis several imaging technologies are used including Mammography, Ultrasonography and Magnetic Resonance Imaging. Mammogram is one of popular technique to identify breast cancer. This paper discusses process used in medical imaging technologies for breast cancer detection.

Keywords: *Magnetic Resonance Imaging, Mammogram and Breast cancer diagnosis*

I. INTRODUCTION

The presence of mammary gland (mamma) is one of the key characteristic features of female mammals that produce milk to feed newly born offspring. The origin of word "Mammals" came from the word "mammary". In humans, the main constituent of breast is the mammary glands. The mammary gland is like a modified and greatly enlarged sweat gland of the skin. This paired organ which looks like a hemisphere is located at the level of the third-sixth ribs. The breast is the region that extends from lateral thoracic artery at the top to the infra-mammary fold at the bottom. The mammary gland has a small projection, the nipple, surrounded by a portion of pigmented skin called the mammary areola.

The breast is one of the most dynamic organs in human. Breast change happens in female in different stages throughout the life, first before birth, again at puberty and during the childbearing years. The basic morphological structures of male and female breasts are determined during the prenatal development stage. For a female, breast development is started at the beginning of puberty due to the influence of female sex hormones principally estrogen. It promotes the sprouting, growth and development of the breasts. The rate at which breasts develop differs greatly and is diverse for each young female. The structure of the female breast varies significantly at different times during a woman's life - before, during and after adolescence, for the duration of pregnancy, during the menstrual cycle and after menopause.

The mature women's breast, the milk-producing system, is made up of 15 to 20 irregular lobes of branched tubuloalveolar glands. Adipose tissue is also present among the lobes. A network of ducts spreads from the lobes towards the nipple. Younger women have more glandular tissue in their breasts, which makes them dense. The breast can be divided into four regions skin, nipple, subareolar tissues; subcutaneous region contains fat and lymphatics; parenchyma region, a triangular shape between the subcutaneous and retromammary regions, with the apex towards the nipple and finally retromammary regionconsists of retromammary fat, the pectoral muscle, ribs, intercostal muscles and the pleural reflection.

The breast is prone to various benign and malignant conditions. The most common benign conditions are puerperal mastitis, fibrocystic breast changes and mastalgia. The latter part is very serious in nature that is Breast Cancer. Breast cancer, a malignant tumour developed from breast cells is considered to be one of the major causes for the increase in mortality among women, especially in developed and developing countries. More specifically, breast cancer is the second most common type of cancer and the fifth most common cause of cancer-related death. So, it continues to be a significant public health problem in the world.

Cancer is a group of diseases that cause cells in the body to change and grow out of control. Most types of cancer cells eventually form a lump or mass called a tumour, and are named after the part of the body where the tumour originates. Breast cancer begins in breast tissue, which is made up of glands for milk production, called lobules and the ducts that connect lobules to the nipple.

Most masses are benign, that is, they are not cancerous, do not grow uncontrollably or spread and are not life-threatening. Some breast cancers are called in situ because they are confined within the ducts (ductal carcinoma in situ) or lobules (lobular carcinoma in situ) of the breast. Nearly all cancers at this stage can be cured. Many oncologists believe that lobular carcinoma in situ (also known as lobular neoplasia) is not a true cancer, but an indicator of increased risk for developing invasive cancer in either breast. Some cancerous breast tumours are invasive or infiltrating. If the cancer has broken through the basal membrane and spread into the surrounding tissue it is called invasive.

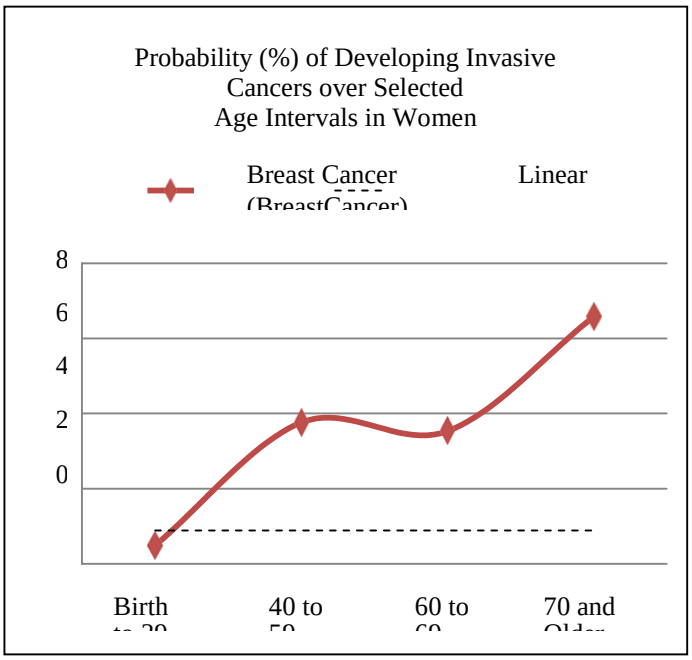

Figure 1 showing sharp increasing probability of Breast Cancer

These cancers start in the lobules or ducts of the breast but have broken through the duct or glandular walls to invade the surrounding tissue of the breast. The seriousness of invasive breast cancer is strongly influenced by the stage of the disease, that is, the extent or spread of the cancer when it is first diagnosed. The breast cancer in women is one of the most challenging health hazards that the world is facing today. The gender is the most significant factor affecting the possibility of one developing breast cancer. High blood levels of estrogen have been related with breast cancer. Women are more likely to develop breast cancer than men. Besides gender, age is the next most strongly connected risk factor of breast cancer. It has been widely accepted that the elderly women are more susceptible to breast cancer than young. It is shown in figure 1.

Breast cancer – Signs and Symptoms

In early stage of breast cancer there are no visual or any significant symptoms, however, if diagnosed it is the right time for curative treatment because the size of the tumour is small. Even some time large tumours in breast may be painless. According to Cancer Facts and Figures 2012, USA stated that the less common symptoms include persistent changes to the breast, such as thickening, swelling, distortion, tenderness, skin irritation, redness, scaliness or nipple abnormalities, such as ulceration, retraction or spontaneous discharge. Typically, breast pain results from benign conditions and is not an early symptom of breast cancer [1].

Growing age increases the risk factor almost in exponential order in females. Definite cause of breast cancer is still not identified, so, prevention becomes impossible. Early stage detection is more effective for affecting treatment and increases the probability to be cured rapidly. Several studies have shown that early detection saves live and increases treatment opportunities. It is also evident that early detection and improvements in treatment can decrease the rate of mortality among women considerably.

Breast Cancer -Diagnosis

Breast cancer stages range from 0 to IV. The higher the staging number, the more advanced the cancer. The seriousness of invasive breast cancer is strongly influenced by the stage of the disease, that is, the extent or spread of the cancer when it is first diagnosed. Early and efficient diagnosis is the most effective way for treatment and to reduce mortality. The breast cancer diagnosis process is basically two folds. The screening process is simply used to find abnormalities in the breast. The conclusion reached through process of analysing histopathological slide with present technologies and procedures like biopsy to determine whether a tumour is malignant or benign.

Breast cancer screening is a professional medical examination performed to check women's breasts for abnormalities such as calcification, tumours and cysts, and identify where they exist. Several screening techniques can be used to examine the breast including

Ultrasound imaging, which uses a band of high frequency sound waves to probe the breast, Magnetic Resonance Imaging (MRI), which probes the breast using powerful magnetic fields and Mammography, which is essentially producing X-ray photographs of the breast.

Digital mammography is a recent technique for recording x-ray images in digital code instead of on x-ray film, as with conventional mammography. Digital mammography has some advantages over conventional mammography. The images are displayed on a computer monitor and can be enhanced before they are printed on film. Images can also be manipulated; the radiologist can magnify or zoom in on an area. The images can be stored and retrieved electronically, which makes long-distance consultations with other mammography specialists easier. Digital Mammography has been proved to be the most effective and reliable screening method for early breast cancer detection.

Imaging techniques play an important role in helping to perform breast biopsies, especially of abnormal areas that can be identified and located by a mammogram. There are several types of biopsies present, like vacuum-assisted biopsy (Mammotome) or core needle biopsy, but traditional open surgical biopsy is the gold standard to which other methods of breast biopsies are compared. Surgical breast biopsy takes the largest tissue sample and has the highest accuracy rate of all biopsy methods. A pathology lab can use two methods to study cancer tissue sample. The quickest method is called "frozen section" or cryosection. A permanent section method is a more thorough process, using special chemicals to get more information from the histopathological slide of tissue.

Mammography

Mammography is a low Intensity X-ray procedure that allows visualisation of the internal structure of the breast. Mammography is highly accurate, but like most medical tests, it is not perfect. On average, mammography will detect about 80% - 90% of the breast cancers in women without symptoms. Testing is somewhat more accurate in postmenopausal than in premenopausal women [2]. The mammography first came into being in the year 1960’s and recorded analog X-ray image of breast. In the year 1976, commercial use of mammography system started for breast screening service.

Various Technologies

Same as other radiographic technique, an X-ray beam is passed through the breast tissue to record the variations in amounts of radiation that are absorbed. Since dissimilar tissues in the breast absorb diverse amounts of radiation, resulting distinguished features and details about the tissues can be analysed. In screening mammography each breast is compressed into a relatively flat surface and an X-ray source on one side of the breast produces radiation through the breast. On the other side of the breast the radiation is recorded on screen film or by a semiconductor device. Two types of mammographic technologies are used one is Screen Film mammography and another is digital mammography for detecting breast cancer[21-23].

Screen Film Mammography

Screen Film mammography is also known as traditional mammography and is the conventional method that stores x-ray images on film. The traditional technology has some notable advantages. It is comparatively inexpensive, simple technology and equipment, produces images with acceptably good resolution. It is old technology, so, it is available throughout the country. But it has some inheriting disadvantages also. It requires film which can be used for single use only for processing and at the same time it is time consuming too. A large amount of physical storage space is required to preserve the film for future reference.

Digital Mammography

With the revolutionary development in the field of digital technology and optical electronics in later part of the twentieth

century, Digital mammography came into existence and promises a fully digital solution. Digital mammography is a technique for recording x-ray images in digitised code instead on x-ray film as with conventional mammography. The images are displayed on a computer monitor and the image can be processed before they are printed on film. Images can also be manipulated; the radiologist can magnify or zoom in on an area. From the patient's perspective, the procedure for a mammogram with a digital system is the same as for conventional mammography [3].

Digital mammography has advantages over conventional mammography. The images can be stored and retrieved electronically which makes long-distance consultations with other mammography specialists easier. Because the radiologist can adjust the images, subtle differences between tissues may be noted. Despite these benefits, studies have not yet shown that digital mammography is more effective in finding cancer than conventional mammography. The first digital mammography [4] system received U.S. Food and Drug Administration (FDA) approval in 2000. The pioneer manufacturing companies of digital mammographic system are General Electric Medical Systems (Senographe 2000D approved 28/1/2000) [5], Fischer Imaging (SenoScan approved 19/11/2001) [6] and Lorad (Lorad Digital Breast Imager approved 15/3/2002) [7].

Mammographic Projection

The projection of the breast can be made from different angles. The two most common projections are medio-lateral oblique (MLO) and cranio-caudal (CC). The medio-lateral oblique projection orientated along the horizontal axis shows the entire gland where the cranio-caudal projection, which is positioned along the vertical axis of the body, shows central and inner breast tissue. In the MLO views there is one non-breast region may be present in the left or right corner of the image called pectoral muscle.

The mammogram image segmented the breast regions according to density of the tissues that is represented on image by intensity of pixel. X-ray radiation is attenuated at a greater rate by denser regions such as muscles, fibro-glandular tissue, malignant and benign masses and vascular tissue. In contrast, less dense material, such as fat tissue or skin attenuates X-rays less resulting manifests as dark regions.

Mammogram Screening Program

Mammography screening associated with clinical breast examination is the only viable and effective method to detect early breast cancer which can result in reduction in mortality. In view of that several developed countries have started the mass screening programme for their citizens. According to World Health Organisation (WHO) the concept of screening in health care – that is, actively seeking to identify a disease or pre-disease condition in individuals who are presumed and presume themselves to be healthy – grew rapidly during the twentieth century and is now widely accepted in most of the developed world. Used wisely, it can be a powerful tool in the prevention of disease.

In US, the National Breast and Cervical Cancer Early Detection Program (NBCCEDP), the Centers for Disease Control and Prevention (CDC) provides low-income, uninsured andunderserved women access to timely breast and cervical cancer screening and diagnostic services. To improve access to screening, Congress passed the Breast and Cervical Cancer Mortality Prevention Act of 1990, which guided CDC in creating the NBCCEDP. Currently, the NBCCEDP funds all 50 states, the District of Columbia, 5 U.S. territories, and 12 American Indian/Alaska Native tribes or tribal organisations to provide screening services for breast and cervical cancer. An estimated 9.7%–11% of U.S. women of age of 40 to 64 are eligible to receive NBCCEDP services. In program year 2011, the NBCCEDP screened 333,302 women for breast cancer with mammography and diagnosed 5,655 breast cancer cases [8]. According to American Cancer Society, it has been recorded that a steady decline in breast cancer mortality among women since 1990 [1]. This decline is the success story of such early detection programme and improvements in treatment.

The breast screening programme in Australia exists to target women between 50 and 69 year of age (although the scheme is available for all women over 40) at a recommended screening interval of 24 months. In the years 1997 and 1998, 54.3% of women in the target age group were screened. The target of Breast Screen Australia is 70% [9].

Most of the European Countries have started their mass screening programme. According to the report published by World Health Organisation (WHO) 2006, on behalf of the European Observatory on Health Systems and Policies, in France, screening for breast cancer, started in the year 2002, has been extended since January 2004. Every woman between 50 and 74 years is invited for a free breast screening every two years. Outcome is extremely good showing reduction of the percentage of late-stage breast cancer detected in women, notably by increasing the screening coverage rate up to 80% in women aged between 50 and 74 years. In Belgium, based on the directives developed by Europe Against

Cancer, the three Communities and the Federal Government signed a protocol, in October 2000, to organise and finance a national campaign of breast cancer screening for women aged 50–69 years [1]. United Kingdom, Denmark, Finland, Greece, Italy, Netherland, Spain, Sweden, Bulgaria, Czech Republic, Hungary and others countries of Europe have started the mass screening programme that are running successfully.

This enormous achievement by developed countries and growing threat of breast cancer, the developing countries are also encouraged to plan and implement mass screening programmes for their citizens. As a result of mass screening programme a large number of images will be generated. The load on radiologists is expected to increase in the future due to the increasing proportion of women using the service. Large countries like India, this kind of programme will emit huge data for interpretation but the number of radiologists or trained technicians is very limited. This situation can only be handled by using some sort of inexpensive automated analytical tools for assistance in interpretation of these massive data. The appropriate and efficient solution may be a Computer Aided Diagnosis (CAD) system which will be fully autonomous, time saving and cost effective too.

Computer Aided Diagnosis (CAD)

Now a day's computer is a tool used in every discipline of study to solve critical problems. Different inter-disciplinary subjects are evolving which is dealing with super specialised area of knowledge. Computer technology has had a tremendous impact on medical imaging. Radiology is using computer in the field of image interpretation process which introduces new flexibility into the system. This inter-disciplinary field is known as medical image processing and computer aided diagnosis (CAD) is the outcome of the same. By definition a CAD is a set of automatic or semiautomatic tools developed to assist radiologists in the detection and / or evaluation of

medical images. Digital mammography accompanied with CAD can reduce huge work load on radiologists. CAD systems are not intended to replace radiologist but rather to assist them during image evaluation by prompting suspicious regions of breast.

Mammogram CAD Development

The analysis of radiographic images using computer assistance is not new idea [10]. In 1964, to determine the cardio-thoracic ratio on chest radiographs Meyers et al. [11] proposed an autonomous system. In 1967, a system for automated analysis of mammograms based on bilateral comparison was developed by Winsberg et al. [12]; it was useful in screening normal examinations of mammography with routine viewing. An algorithm for detection of micro-calcifications on mammograms was developed by Tasto et al. [13] in 1975, which were based on grey scale identification in a mammogram. These are some early evidence of CAD in radiology. Later with revolutionary development of digitisation techniques, improvement in the field of digital image processing algorithms and sufficient speed of computational power started to make practically feasible CAD applications.

The first CAD device to receive FDA approval, the ImageCheckerM1000® by R2 Technology, Inc. (Los Altos, CA), was approved by premarket application (PMA) approval (P970058) on June 26, 1998. The initial product labelling was for use on routine screening mammograms, but on May 29, 2001, approval was granted for the expansion of the "Indications for Use" to cover diagnostic as well as screening mammograms [14]. Contemporary Academic Initiatives on Mammogram CAD Looking at the need of the CAD system especially in the field of breast cancer research several government and non-government initiative has been started all over the world. Several well-known universities and research institutes have worked or are working extensively in the area of mammogram CAD systems.

Commercial Viability of Mammogram CAD

Since 1998, when four mammographic CAD systems received FDA approval in US, several commercial initiates have started to develop mammographic CAD software as aid to medical practitioners around the world. Pioneer in this field is Image Checker of R2 Technologies Inc. [15]. Two widely popular mammographic CAD systems CADx Second Look and iCAD Mammo Reader came in to market in 2002; later both are merged together [16]. In the year 2004, another well-known CAD system arrived that was KodaK Mammography CAD Engine [17]. Later on several renowned organisations like Arcadia Lab, Fujifilm and Siemens came out with their own Mammographic CAD software solutions like Galileo CAD software [18], Digital Mammography CAD System [19], Syngo Mammo CAD [20] respectively. However, it may be predicated that several commercial software's will be available in near future due to necessity and commercial possibility.

CONCLUSIONS

Breast cancer in women is one of the most challenging health hazards especially affecting the ageing females has been discussed. It is not only the problem of developing countries but it is also becoming major health related challenge in developing countries like India, China etc. The cause of breast cancer is yet to be determined, so concrete prevention is unavailable. The early and efficient detection are the only way towards successful treatment. Screening technology using digital mammography is the recent and most popular technique among the medical practitioners. It is treated as the gold standard among all other alternatives. For confirmation, however, surgical biopsy is performed for accurate localisation. This helps for proper direction and accuracy towards successful diagnosis. The medical imaging technology is a mandatory part of clinical diagnosis of breast cancer. Digital Mammography is the most preferred imaging technology for early detection of breast cancer. It is called the gold standard for breast cancer diagnosis. Digitisation has helped in the development of the computer aided diagnosis (CAD) as an emerging interdisciplinary field of study for several disease detection and analysis including breast cancer. Several works on Mammogram CAD technology are undergoing and numerous efforts will be done in near future in view of scarcity of medical professionals and to assist the development of futuristic healthcare systems like telemedicine etc. CAD is the only solution to face the future problems due to its efficiency, accuracy and cost effectiveness. There are huge opportunities still left for further advancement and enhancement of the same.

References

[1] American Cancer Society, "Cancer Facts & Figures", Atlanta: American Cancer Society, 2012.

[2] Michaelson et al, "The pattern of breast cancer screening utilization and its consequences", Cancer, Vol. 94, Issue-1, pp. 37-43, 1 Jan,2002

[3] United States Food and Drug Administration, www.accessdata.fda.gov

[4] Web site of National Cancer Institute (NCI),www.cancernet.gov

[5] United States Food and Drug Administration approval document, "Senographe 2000D Full Field Digital Mammography System", no. P990066, Jan2000

[6] United States Food and Drug Administration approval document, "SenoScan Full Field Digital Mammography System", no. P010017, Sep2001

[7] United States Food and Drug Administration approval document, "Lorad Digital Breast Imager (LDBI)", no. P010025, Mar2002

[8] Centers for Disease Control and Prevention, a division of Cancer Prevention and Control, National Breast and Cervical Cancer Early Detection Program (NBCCEDP), official website:www.cdc.gov

[9] American Cancer Society, "Cancer Facts & Figures", Atlanta: American Cancer Society,2012- Australian Institute of Health and Welfare, "Breast Screen Australia Achievement Report1997-1998", Cancer Series 13, No. CAN 8, Canberra: Australian Institute of Health and Welfare,2000

[10] Bick et al, "Tutorial on Computer Aided-Diagnosis", Computer Aided Diagnosis Tutorial, CARS 2000, Hyatt Regency: San Francisco, USA,2000

[11] Meyersetal,"Automatedcomputeranalysisofradiographicimages",Radiology, Vol. 83, pp. 1029-1033, 1964

[12] Winsbergetal,"Detectionofradiographicabnormalitiesinmammogramsbymeans of optical scanning and computer analysis", Radiology, Vol. 89, pp. 211-215,1967

[13] Tasto, "Automatische Mammographie - Auswertung: Erkennung von Mikroverkalkungen", Biomedizinische Technik, Vol. 20, pp. 273-274,1975

[14] Technology Evaluation Center, "Computer-Aided Detection (CAD) in Mammography", Assessment Program, Vol. 17, Issue-17, Dec,2002

[15] R2 ImageChecker,www.r2tech.com

[16] iCAD Second Look,www.icadmed.com

[17] Kodak , www.kodak.com
[18] Arcadia Lab, www.arcadialab.com
[19] FUJIFILM,www.fujifilm.com
[20] Siemens,www.medical.siemens.com
[21] Mohebian, M.R.; Marateb, H.R.; Mansourian, M.; Mañanas, M.A.; Mokarian, F. A hybrid computer-aided-diagnosis system for prediction of breast cancer recurrence (HPBCR) using optimized ensemble learning. Comput. Struct. Biotechnol. J. 2017
[22] Lewis, T.C.; Pizzitola, V.J.; Giurescu, M.E.; Eversman, W.G.; Lorans, R.; Robinson, K.A.; Patel, B.K. Contrast-enhanced digital mammography: A single-institution experience of the first 208 cases. Breast J. 2017
[23] Nassar, F.J.; Nasr, R.; Talhouk, R. Micrornas as biomarkers for early breast cancer diagnosis, prognosis and therapy prediction. Pharmacol. Ther. 2017, 172, 34–49.