Benedito Rodrigues da Silva Neto
(Organizador)

Alicerces e Adversidades das Ciências da Saúde no Brasil 4

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APRESENTAÇÃO

A coleção "Alicerces e Adversidades das Ciências da Saúde no Brasil" é uma obra composta de cinco volumes que tem como foco as bases e as interfaces multidisciplinares dos trabalhos desenvolvidos em diversos locais do país que compõe os diversos capítulos de cada volume. De forma categorizada os trabalhos, pesquisas, relatos de casos e revisões tentarão demonstrar ao leitor os princípios de cada área da saúde assim como suas peculiaridades.

Apresentamos aqui o quarto e último volume desta obra tão relevante e interessante para todos aqueles que se interessam pelos atuais alicerces aos quais as ciências da saúde tem se sustentado no Brasil. Diversos eixos foram abordados nos volumes anteriores, e complementando este volume final trás consigo temas como Hanseníase, Neurogênese, Políticas públicas. Saúde, Continuidade da Assistência ao Paciente, Câncer Ginecológico, Filariose Síndrome de Meigs, Glioma, proteômica do câncer, Bioética, Alocação de recursos para atenção em saúde, Trauma de membros inferiores, Infecções Bacterianas, Doenças Negligenciadas, Carcinoma hepatocelular, Hepatite, Triatomineos, Vigilância Entomológica, Biomarcadores, Sistema Internacional de Estadiamento e Metodologias ativas.

A fundamentação, e o estabelecimento de conceitos e padrões básicos é muito importante na ciências da saúde uma vez que novos estudos e pesquisas tanto de revisão quanto experimentais sempre se baseiam em técnicas e fontes já publicadas. Assim, destacamos a relevância deste material com informações recentes sobre diversas temáticas da saúde.

Portanto a obra "Alicerces e Adversidades das Ciências da Saúde no Brasil 2" oferece ao leitor teoria bem fundamentada aliada à resultados práticos obtidos pelos diversos grupos de pesquisa em saúde do país, que arduamente desenvolveram seus trabalhos aqui apresentados de maneira concisa e didática. A divulgação científica de qualidade, em tempos de fontes não confiáveis de informação, é extremamente importante. Por isso evidenciamos também a estrutura da Atena Editora capaz de oferecer uma plataforma consolidada e confiável para estes pesquisadores apresentarem e divulguem seus resultados.

Desejamos à todos uma excelente leitura!

Benedito Rodrigues da Silva Neto

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EARLY DETECTION OF BREAST CANCER SAVES LIFE: A REVIEW OF MICROWAVE IMAGING AGAINST X-RAYS MAMMOGRAPHY

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ABSTRACT: Breast Cancer is the deadliest disease among all the types of cancer. Every second woman is in danger in Canada and every 8th women in Pakistan and USA. Therefore, it need to focus on this issue seriously, from diagnosis till the cure very carefully. Mammography is a potential tool for breast cancer screening, works on ionizing X-rays exposure on skin which is one of the dark side of mammography. Whereas the other features like early detection, detection in dense breast or in pregnant woman is still not really satisfactory with mammography. After 40 years of age, every woman must pass through screening once in a year but American Cancer Society did not allowed Mammography in a period of two years. In the light of these facts, Scientist think that there is a desperate need of an alternating technique, that is Microwave Imaging (MWI). MWI is non-ionizing technique for diagnosis of breast cancer at early stage which is suitable for all age groups and size of breast but still under developed. The early detection of breast cancer can save the life. The technique depends on the contrast of dielectric properties of the cancerous and healthy tissues and do not need compression of the breast for diagnosis

which make it user friendly. For mammography, usually the biopsy is need for results confirmation therefore its expensive too but MWI is cost effect also.
KEYWORDS: Microwave Imaging, Non-Ionizing, Breast Cancer.

DETECÇÃO PRECOCE DO CÂNCER DE MAMA SALVA A VIDA: UMA REVISÃO DA IMAGEM DE MICROONDAS CONTRA A MAMOGRAFIA DE RAIOS X

RESUMO: O câncer de mama é a doença mais letal entre todos os tipos de câncer. Toda segunda mulher está em perigo no Canadá e a cada oito mulheres no Paquistão e nos USA. Portanto, ele precisa se concentrar nesta questão a sério, desde o diagnóstico até a cura com muito cuidado. A mamografia é uma ferramenta potencial para o rastreio do cancro da mama, trabalha na exposição de raios-x ionizantes na pele, que é um dos lados escuros da mamografia. Considerando que as outras características, como detecção precoce, detecção em mama densa ou em gestante ainda não é realmente satisfatória com a mamografia. Após os 40 anos de idade, todas as mulheres devem passar pela triagem uma vez por ano, mas a American Cancer Society não permitiu a mamografia em um período de dois anos. À luz destes factos, o cientista pensa que existe uma necessidade desesperada de uma técnica alternada, isto é, a Imagiologia por Microondas (MWI). A MWI é uma técnica não ionizante para o diagnóstico de câncer de mama em estágio inicial, que é adequada para todas as faixas etárias e tamanho da mama, mas ainda está subdesenvolvida. A detecção precoce do câncer de mama pode salvar a vida. A técnica depende do contraste das propriedades dielétricas dos tecidos cancerosos e saudáveis e não necessita de compressão da mama para o diagnóstico, o que a torna amigável. Para mamografia, geralmente a biópsia é necessária para confirmação de resultados, portanto, é caro também, mas o MWI também é um efeito de custo.
PALAVRAS-CHAVE: Imagem de microondas, não-ionizante, câncer de mama,

1 I INTRODUCTION

Cancer is a group of diseases characterized by the uncontrolled growth and spread of abnormal cells. Breast cancer is the most commonly diagnosed cancer in women and has the highest incidence of cancer in women [LIAQAT, 2017]. In the world, 1.7 million patients (male and female) were diagnosed with Breast cancer during 2018 out of which 15% are from United States reported by American Cancer Society [American Cancer Society, 2016]. This disease ratio is about 0.3% bit high in black women [American Cancer Society, 2016]. In Pakistan, 40,000 breast cancer patients out of 90,000 are died in 2018 which means 16.1% people are affected by this disease Figure 1. One major reason of this high ratio in Pakistan is lack of availbility of yearly screening in Pakistan. Therefore, it need to focus on this issue seriously, from diagnosis till the cure very carefully. At early stage detection can increase the survival rate of patient by 90% [Cancer Society, 2014]. But unfortunately we do not have efficient tools for early detection till now.

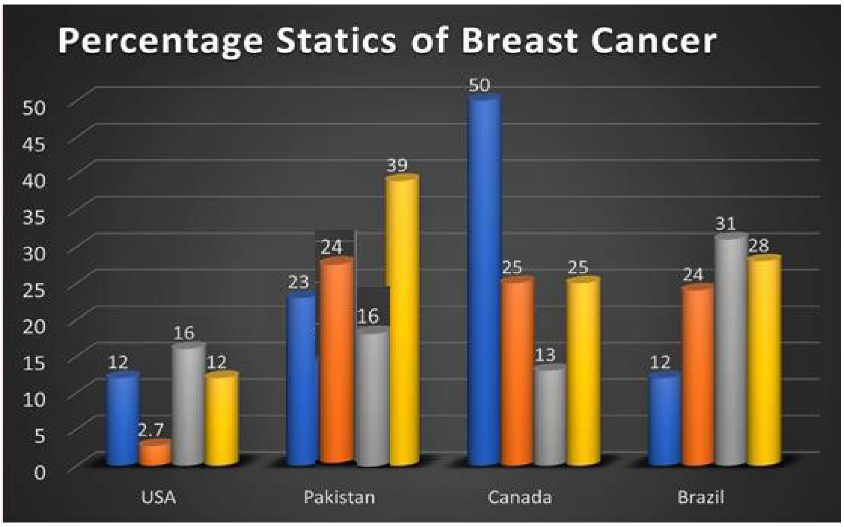

Figure 1: Probability of Breast Cancer (blue bar), Death Rate in Past (orange bar) Death rate till 2018 (Gray line) and Percentage among all cancer Types (Yellow Line)

Source: Official Sites of USA, Pakistan, Canada and Brazilian Cancer Societies

Detection of cancer can be done in various ways and usually depends on the stage in which the cancerous tumors are traced. It is a common understanding that the diagnostic of early stage breast cancers depends on population access to advanced medical care for examine. Basic methods like x-rays, ultrasound, computed tomography (CT) scan, positron emission tomography (PET), magnetic resonance imaging (MRI) scan, microwave imaging (MWI) and biopsy are used in detecting tumors in the initial stages. Ionizing x-rays of 30 KVp are used to diagnose breast cancer and this technique is known as X-ray Mammography [Zhang, 2014]. Low contrast images recorded for diagnosis [Zhang, 2014]. This process is beneficial with respect to process time whereas, it's painful and has a high ratio of false results [3]. Due to ionizing nature of the source of x-rays, it may be harmful to healthy tissues in the surrounding of cancerous tissues. The resolution of the resulting images is sufficient for the most diagnostic requirement, but not enough for a high dense breast [Zhang, 2014].

Ultrasound imaging relies on high frequency sound waves that reflect with varying intensity from different tissues. It's a good tool to distinguished among skin, fats, muscles and glandular tissues of breast. However, for a number of reasons, ultrasound has yet to prove itself as an effective breast cancer screening methodology, despite improvement in recent years. Main issue for using ultrasound, the acoustic properties of normal and abnormal tissues of breast fats are almost same which make it difficult to handle [LIAQAT, 2017]. Another limitation is the hand-handled device of ultrasound to use, the highly efficient person is required otherwise the results will be false. As a result, ultrasound primarily remains a tool for distinguishing cysts and guiding biopsy procedures. Until new techniques are developed that resolve these and other issues, ultrasound cannot be considered as an effective widespread screening method for breast cancer. Only the expert doctors can detect breast cancer using ultrasound imaging. Ultrasound Imaging System is based on the use of ultrasonic wave ranging from 1MHz to 15MHz.Whereas, the deep and solid tumor cannot be detected using this technique. The resulting images can be in any orientation due to real-time screening.

For painless body scan, Ultrasounds can be used in the range of 20 KHz. It works on the detection of pulse echoes produced by transduce and produce image without the effect of radiation exposure. But its resolution is very low, almost failed to differentiate between malignant and benign tumor and it's also applicable for young patients (less than 50 years) [Liaqat, 2017]. That is the reason; it's used just for supporting technique for suspected mass reported in mammography. MRI is based on the use magnetic field pathological image. Several small scanner devices placed around the breast to examine. The high sensitivity of MRI provides extremely high-resolution images for soft tissues, and especially for small tumors. However, its high cost and the time-consuming diagnosis process are major shortcomings. The advantages and disadvantages of the diagnostic method can be classified as cost, safety, accuracy and scope of application. MRI used radio waves in strong magnetic field can use for screening of breast which expensive. For better results of this technique, contrast agents are used to enhance the absorption of radiation for soft tissues like breast. Its again a used for mammography results verification before operate like breast-conserving lumpectomy to mastectomy [Liaqat,2017].

For detection, X-rays are used as a source of radiation, two plates squeezed the breast to reduce the exposure per unit volume in Mammography. Images of the breast are then recorded on film for diagnosis. This process is efficient in terms of time but due to compression of breast, its painful. Besides, the high levels of ionizing radiation involved are harmful to patients, and may even cause cancer in healthy tissues. The resolution of the resulting images is sufficient for most diagnostic requirement, but not enough for a high dense breast. X-rays are good to use with care and only the expert radiologist are required for better working results and minimum exposure of radiation. The X-ray mammography exam plays important rule as gold-standard medical imaging on these diagnostics [Liaqat, 2017]. It must be point out that approximately 15% of the diagnostics resulted from x-ray mammography are missed and the image-guide biopsy exam results 75% false diagnostics, in special false positives. X-ray mammography is still limited in contrast because of high scattering of radiation by breast tissues (blurring) and the low repeatability to avoid undesired radiobiology effects in patient [Turkmen, 2011].

Another Imaging technique is PET which required some kind of radioactive biomarkers. Radiotracers are used in PET scanning. PET is a type a nuclear medicine imaging which is able to pinpoint the exact point or position using the biomarkers with

PET imaging. PET can detect at early stages which is hard with other techniques. However, it has low resolution. The limitations discussed above forced scientist to developed an alternating technique for breast cancer diagnosis which is under developed till now is known as Microwave Imaging (MWI) and its harmlessness for human [KWON, 2013]. X-ray mammography, the has drawbacks: ionizing nature of source radiations, has painful method, not good for young patients and high rate of false-positives. MWI uses the scattered waves arises from the contrast in dielectric properties between normal and malignant breast tissues. The limitations of these three methods have motivated researchers to develop a more effective, lower ionizing and low-cost diagnosis method for cancer detection.

For this purpose, microwave imaging has become a potentially significant method which will be discussed in detail in next section. In this article, make review about MWI and other techniques. First, we review studies of breast tissue properties in the microwave region. This article presents initial results aiming the development of a cost-effectively flexible MWI system for breast cancer diagnostics. Microwave imaging for medical applications has been extensively researched in the last years. With this technique, MW signals are used to illuminate biological tissue, reflected or scattered fields are recorded and used for image reconstructions. MWI could works due to difference in dielectric properties between malignant tissue and normal breast tissue. Its user friendly and low cost, highly efficient for all age groups, for early stage detection and no safety hazards required and can make early screen affordable. The results of MWI are given in next section.

BREAST TISSUE DIELECTRIC PROPERTIES IN THE MICROWAVE RANGE: The study of breast dielectric properties, and research results have already been published. The difference between malignant and normal breast tissues is large; and these have been demonstrated by Joines et al.1980, 1994; Chaudhary et al. 1984; and Surowiec et al. 1988. The dielectric properties of malignant and normal breast tissues are shown in Figure 2. Different groups in the world like the Chaudhary et al. 1984, the collect data from 15 patients and judge breast tissues at 12GHz are 3-5 times greater than normal breast tissues [CHAUDHARY, MISHRA and THOMAS, 1984]. Joines et al.1994 predict the ratio of malignant and normal tumor at 900MHz about 200-500%, [SUROWIEC, et al., 1988]. The dielectric properties of normal breast tissues are approximately ten times as less than as malignant breast tissues Figure 2. The normal breast tissues is contain less amount of water and less active but malignant tissues has high concentration of water which make these more active [GABRIEL, LAU and C. GABRIEL, 1996] [POSTOW and POLK 1996].

However, the earlier studies and research were small-scale. Later, from the University of Wisconsin and the University of Calgary in 2007 reported dielectric properties in UWM frequency range for malignant breast tissues, benign and normal breast tissues at large scale [LAZEBNIK, MCCARTNEY and POPOVIC, 2007]. The total number of patients was 93, and give the total number of samples was 488. In this case, the first study gained tissues from reduction surgeries. In the latter study, the total number of patients involved in the study was 196, and the total number of samples was 319, and the tissues were collected from cancer surgeries. In this study they measure the frequency range of dielectric constant data in the 0.5-20 GHz and found that while malignant tissues were ten times larger than adipose-dominated tissues, and only around 10% difference between malignant and normal glandular or fibro connective tissue.

Dielectric Properties of malignant span a small rang and the dielectric properties of normal tissues span a very large range, from 0-30% (the high water content group) adipose tissues to 85-100% (the low water content group) adipose tissues. Figure 2 depicts the dielectric properties of 0-30% as a dot lines and 31-84% adipose as dashed lines and 85-100% adipose tissues as solid lines. Three separate analyses were conducted. In all cases, we considered only those malignant samples that contained ≥30% malignant tissue. The first analysis included all samples where the adipose tissue content was ≤10% [LAZEBNIK, MCCARTNEY and POPOVIC, 2007]. The second analysis was identical to the first but also included a term in the model to adjust for the per cent of fibro-connective tissue. The third did not restrict the per cent adipose tissue and did not adjust for fibro-connective tissue content. Median dielectric constant and effective conductivity dispersion curves were obtained for each group. The previous work of dielectric properties compared with this dielectric properties work. The previous work is similar to the dielectric properties of malignant tissue results, unlike the dielectric of normal breast tissues [LAZEBNIK, MCCARTNEY and POPOVIC, 2007]. Difference of dielectric properties between normal malignant tissue and normal tissue to be close to 10 times, but in large-scale experiments found that the difference was much smaller. In recent time, microwave imaging is still used to distinguish breast cancer [KLEMM et al., 2011] [LAI et al., 2011] [MOLL et al., 2014].

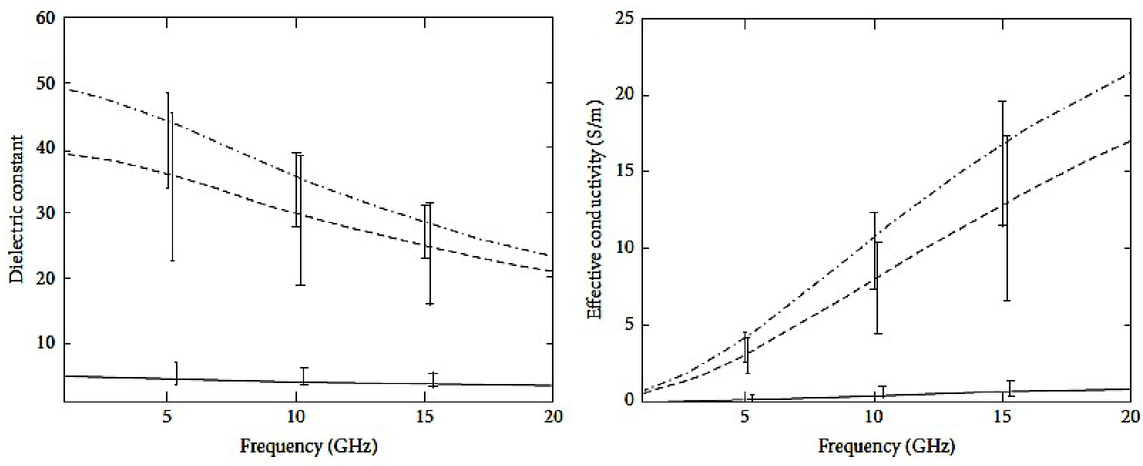

FIGURE 2: Dielectric properties of normal breast tissue samples obtained the reduction surgeries and cancer

Source: M. Lazebnik, L. McCartney, D. Popovic et al., "A large-scale study of the ultra wideband microwave dielectric properties of normal breast tissue obtained from reduction surgeries," *Physicsin Medicine and Biology*, vol. 52, no. 10, p. 2637, 2007.

Several groups of study and research on cancer by using microwave imaging technique to distinguish brain tumor and breast cancer around the global. MWI has been widely used in many civil, industrial and medical applications, such as non-destructive testing, materials characterization, remote sensing, and medical diagnosis. In medical application, there has been a huge interest in using microwave techniques for the detection of tissues, abnormality, such as breast cancer and brain stroke. Besides, breast cancer classification research in microwave imaging technique has been studied in the National University of Ireland [CONCEIC, et al., 2010][MCGINLEY et al., 2010][HALLORAN et al., 2012][CONCEIC et al., 2012][CONCEIC, et al., 2014].

The research team of University of Wisconsin and University of Calgary [LAZEBNIK, MCCARTNEY and POPOVIC, 2007] was conducted at the ex vivo state. Dartmouth College published the correlation between vivo and ex vivo tissue dielectric properties which were measured during mastectomy procedure which were measured in operating room and after resection in the same location immediately from six women [HALTER, et al., 2012]. The *ex vivo* normal breast tissues obtained from a large number of breast reduction patients [LAZEBNIK, MCCARTNEY and POPOVIC, 2007]. The research was vivo and ex vivo validate the range of properties obtained from ex vivo and in vivo are similar, but the difference between the properties obtained ex vivo decrease when compared the properties measured in vivo [GARRETT and FEAR 2014]. In addition, the research teams from University Calgary and University Wisconsin using measurement system to studying dielectric properties estimation [GARRETT and FEAR 2015][BOURQUI and FEAR 2016][WINTERS et al., 2006].

COLE-COLE MODEL FOR ELECTRICAL PROPERTIES OF TISSUES: Microwave imaging for cancer detection was based on the electrical properties of cancerous and surrounding tissues [HENRIKSSON, 2008]. Cancerous cells or tissues have high water contents as compare to the healthy tissues like fatty tissues [BINDU et al., 2006] [ZHANG, 2015]. Attenuation of microwaves is related to the conductivity of tissues whereas, storability linked with the permittivity when electromagnetic microwaves are interacting with tissues [ZHANG, 2015]. The contrast for relative permittivity and conductivity of malignant to normal breast tissues across 3MHz to the 3GHz range is of 4.7:1 and 5:1 respectively [LAZEBNIK et al., 2007]. The relative permittivity and conductivity of normal, benign and malignant tissues have also been measured in the range between 500MHz to 20 GHz [YBARRA et al., 2007]. From measurements of dielectric properties with respect to specific frequency.

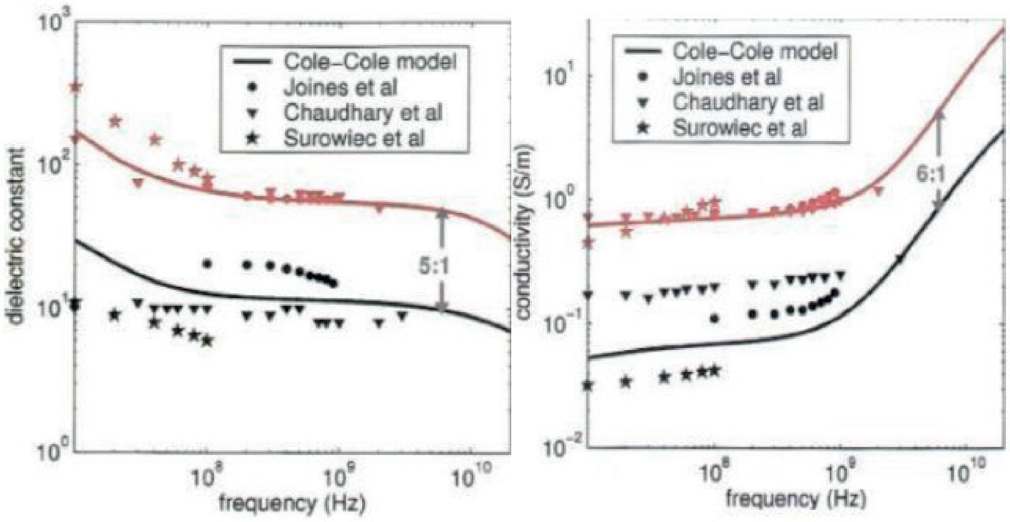

Figure 3: Measured Relative Permittivity and Conductivity. Black: Benign tumor, Red: Malignant tumor.

Source: LAZEBNIK, M.; L. McCARTNEY; D. POPOVIC; C. B. WATKINS; M. J. LINDSTROM; J. HARTER; S. SEWALL; A. MAGLICCO; J. H. BOOSKE; M. OKONIEWSKI and S. C. HAGNESS, A Large -Scale Study of the Ultrawideband Microwave Dielectric Properties of Normal Breast tissue Obtained from Reduction Surgeriesll, Physics in Medicine and Biology, Vol. 52, pp. 2637–2656, 2007

A Cole-Cole model has been developed based on relative permittivity and conductivity of tissues, as given in Equation 3.1 [ZHANG, 2015]. where ω and α are the angular frequency and exponent parameter, ε_s, τ and ε_∞ are static frequency permittivity constants, time constant and infinite frequency permittivity constants respectively. Figure 3, shows that the Cole-Cole model of several studies of the relative permittivity and conductivity of benign and malignant tissues.

$$\varepsilon_\omega = \varepsilon_\infty + \frac{\varepsilon_s - \varepsilon_\infty}{1 + (i\omega\tau)^{1-\alpha}}$$

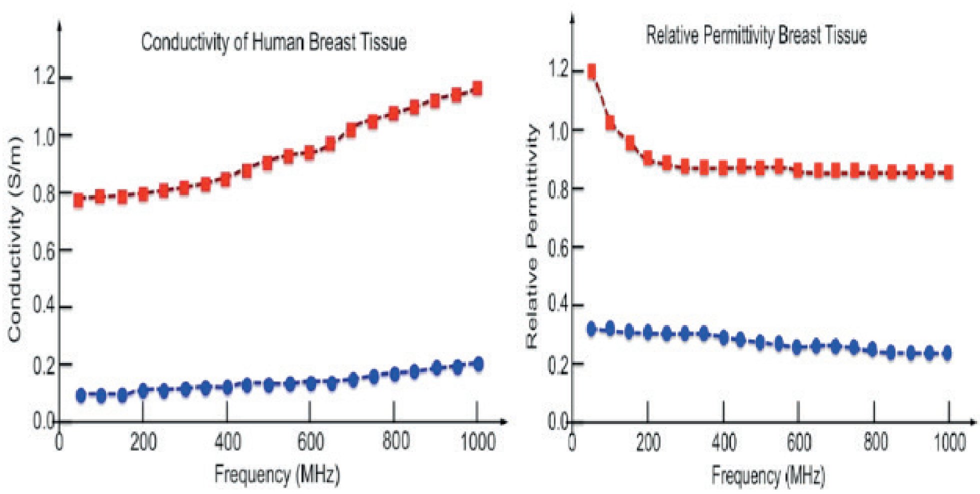

Figure 4: Dielectric Properties of malignant (red line) and healthy (blue line) of human Breast Tissues

Source: YBARRA, G.A; LIU, Q. H.; STANG, J.P.; JOINES, W.T. Microwave Breast Imaging. Emerging Technology in Breast Imaging and Mammography, p. 1-12, 2007.

MICROWAVE IMAGING: One of the factors which can saves the life from breast cancer is early detection which cannot be possible with X-ray mammography or can say hard to achieve with precise due to false results ratio and painful high cost diagnosis along with biopsy. Ultrasonography cannot possible for young patients according to the oncologists. MRI can work only for the extension of repots reliability after mammography as the faded gray scale images of mammography is still under discussion to improve. In developing and under developed countries like Pakistan, Africa, India etc. one major cause of high death rate is due to lack of facilities of yearly screen which is highly recommended by Cancer Societies. Almost 15% screening tests are failed to detect breast cancer using x-ray mammography [BOND, Li and VEEN, 2003]. Due to the limitation of mammography, it is necessary to develop this non-clinical technique. Due to ionizing nature of x-rays, eight out of 1,00,000 patients dies due to yearly screening for a 10 years [HENRIKSSON, 2008].

Therefore, here is a desperate need of an alternating, low cast and more precise tool or technique for diagnosis of breast cancer. Microwave Imaging is an efficient technique for 2D and 3D contrast images which is user friendly and equally efficient for all age groups of the patients. In microwave imaging, backscattered rays are used to identify and locate the tumor in the body, therefore this technique also called radar-based microwave imaging (microwave imaging) [ABDUL-SATTAR and ZUBAIDA, 2012]. Advantages of this technique over mammography are, early stage detection, non-ionizing nature of the source, non-invasive, low cost and more comfortable for patients. UWB Radar imaging of the breast uses the difference in dielectric properties in microwave frequency ranges [ABDUL-SATTAR and ZUBAIDA, 2012].

BASIC THEORY OF MWI: In microwave range, the dielectric properties of malignant and healthy breast tissues and low-loss tissues are used for breast image reconstruction 2D or 3D [DETLEFSONN, DALLINGER and SCHELKSHORN, 2005]. It's totally based on the interactions of microwave between tissues which are fulfill with water whose are an important factor and less fully water tissues are not participate in this process. In the presence of dipole structure the polar and electric charge on water molecules (H2O) is not symmetric.

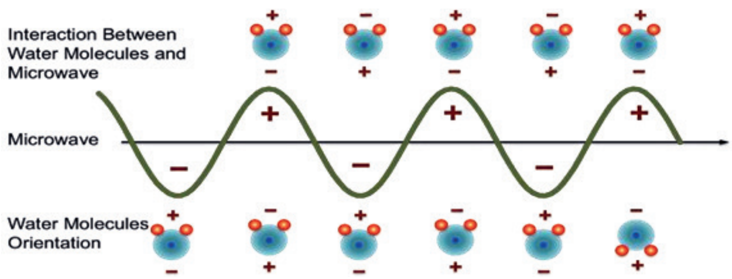

Figure 5: Schematically description the interaction between microwave and water Molecules

Source: http://www.who.int/cancer/detection/breastcancer/en/index2.html

In figure 5 shown, when the electromagnetic radiation interact with breast tissue dipole and will twist as schematically, being early as possible to success resonant conditions. Microwave radiation are used to maximum interaction of electromagnetic wave with water contents inside the breast tissues which are the responsible for sharp the natural frequency of water molecules [LIAQAT, et al., 2017]. Temperature rises because the resonance of microwave in dipole oscillation meets scattering and absorption of microwave energy. Due to overheating, coagulation of cancer is produced. If the field radiation and electrical properties of tissues are known, then its interaction can be studied easily because it's a frequency dependent behavior.

BASIC WORKING PRINCIPLE: For typical microwave tomography, the patient lies on an examination table with the breast through a hole and surrounded by a tank, shown in Figure 6. An antenna array configured in the tank is immersed in coupling liquid to reduce noise and the discontinued electrical boundaries which cause multi-reflections. This the antenna array is composed of several antennas to transmit and receive microwaves.

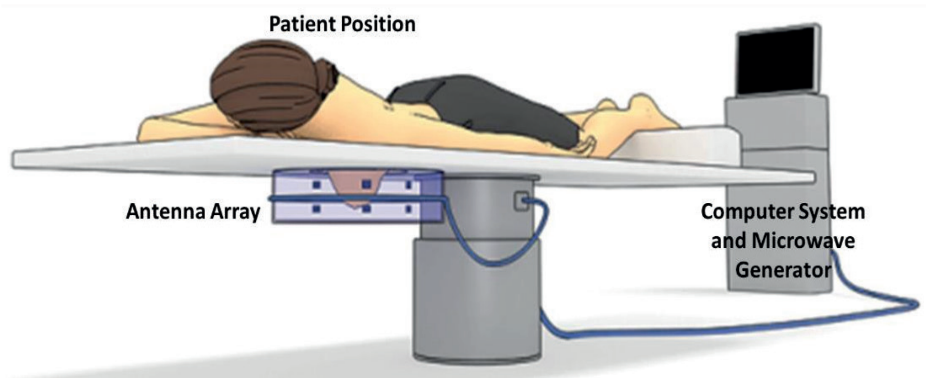

Figure 6: Microwave Tomography

The contrast in electrical properties of healthy and tumor tissues can be used to determine the tumor's position. Normally, a small antenna such as a monopole antenna is used in a microwave tomography prototype to maximize the number of configured antennas. The antenna array rotates vertically in a small step to scan the breast. At each stop position, one antenna is used as transmitting antenna to transmit incident wave and the rest antennas are as receiving antenna to receive scatter wave [ZHANG, 2015]. These received signals are normally processed by the solving of non-linear functions, and this is the most difficult part of microwave tomography. It is worth noting that microwave tomography attempts to reconstruct a map of all electrical properties of the breast, whereas radar-based microwave imaging only focuses on imaging the tumor rather then the whole breast.

MWI is non-ionizing technique and the principle of MWI techniques is based on the contract between dielectric properties, that is, conductivity and permittivity, of healthy and cancerous tissues [SALLEH, et al., 2015]. Few advantages of microwave imaging over mammography are: the ratio of dielectric properties which are of few percentages with mammography whereas with MWI ratio is 2:1 [HANGNESS, TAFLOVE and BRIDGES, 1998]. MWI also helps to detect the size and stage of the tumor as well as locate the tumor position [BOND, LI and VEEN, 2003].

There are two types of MWI:

- Active Microwave Imaging [BERTRAM, et al., 2006]
- Passive Microwave Imaging [YU, FAN, SUN and PICKWELL,2012]

As in the current project, only the active microwave imaging will be under consideration, therefore it will be discussed in detail here. It will be further divided into two categories like Radar Based Imaging or Microwave Tomography approach. Inside the breast the microwave tomography seeks to reproduce the electrical charge for inverse scattering problem. This procedure involves the solving of non-linear functions of mathematical algorithms which causes difficulties in signal processing and reconstruction the image. The radar-based imaging method originates from ground-penetrating radar (GPR) and was proposed to detection cancer (i.e. breast, brain) [ZHANG, 2015]. The main target of radar-based imaging is creating images differentiate between the malignant tissues and surrounding healthy tissues to detection of objects such as tumors.

RADAR-BASED MICROWAVE IMAGING: The basic working of radar-based imaging is on the reconstruction of imaging from the collection of scattered signals in the far field using transmission and receiving antennas of the microwave. Radar-based technique locates the position of the tumor and focused on the image of tumor instead of complete breast. It works well with low frequencies as at a low frequency of electromagnetic radiation penetrates deeper. The returned wave from the object is used to recreate the image by using microwave radar imaging. The returned waves differentiate between the dielectric properties both types of tissues, when waves transmit inside breast [SALLEH, et al., 2015]. Firstly, this technique apply on the human body was developed at the military ground-operating application. The received signals are creating 3D image by concentrate through the principle of breast. In advance to use this principle on breast, preprocessing is applied to check the tumor behavior like tissue loss and radial spread. In this processing received signals not only including the malignant tissues behavior, but other signals may also receive (i.e. antenna coupling, directly signals from the transmit etc.) [BERTRAM, et al., 2006].

ADVANTAGES OF MICROWAVE IMAGING (MWI): Due to poor efficiency and cost of mammography, a cheap, more sensitive and precise solution for breast cancer screening, microwave imaging may be that required technique in near future due to following two reasons: 1) Microwave Imaging is non-invasive and non-ionizing in nature [HENRIKSSON, 2008] and 2) Early stage detection: The observe water level between the disease tissues and healthy tissues [BINDU, et al., 2006]. Therefore, MWI can detect cancer at very early stages and the images produced by MWI are also high in the resolution [KUL, et al., 2005]

- High dielectric contrast for malignant breast tumor [HENRIKSSON, 2008]
- Probably inexpensive [HENRIKSSON, 2008]

IMAGE RECONSTRUCTION USING MWI: The next steps to this project are to develop the system of 8 to 16 array of the antenna in the laboratory for the analysis with heterogenous breast phantoms. The phantom with the dielectric properties of healthy cells and diseased cells will make in laboratory by the technique mention by M. Lazebnik and her group in 2005 [LAZEBNIK, EREST and GARY, 2005]. Then a mathematical algorithm will design for the reconstruction of 2D and 3D image using the backscattered radiations.

MATHEMATICAL ALGORITHMS: Linear Born Approximation is use for reconstruction of image in 3D back scattering of radiations [WANG, et al., 200]. Information of wideband frequency of microwave is obtain in quasi-real time for 3D image of object.

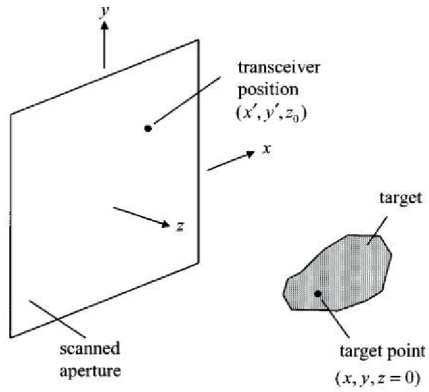

Figure 7: Holographic Imaging system for 2D configuration

Source: Turkmen,M.; Aksu,S.; Cetin,A.E.; Yanik, A.A.; Altug, H. Multi-resonant metamaterials based on UT-shaped nano-aperture antennas. OPTICS EXPRESS.Vol. 19, No. 8 / 7922, 2011.

Whereas for single frequency 2D image is produce on acquisition plane, which is parallel to objective plane as, shown below [TURKMEN, et al., 2011]. Using back-scattering [TURKMEN, et al., 2011] 2D single frequency image reconstruct to near-field microwave imaging. The inverse imaging use Green's function in the form of 3D inverse Fourier transformation (FT) and 3D imge is produced as a set of 2D image in parallel planes [RAVAN, et al., 2010]. Actual principle of inverse imaging is to solve the equations for spatial frequency along x and y-axis (i.e., *kx*, *ky*) under the area of interest. Smaller dimensions of the equations as compare to regular microwave technique reduced the ill-posed nature of problem [RAVAN, et al., 2010].

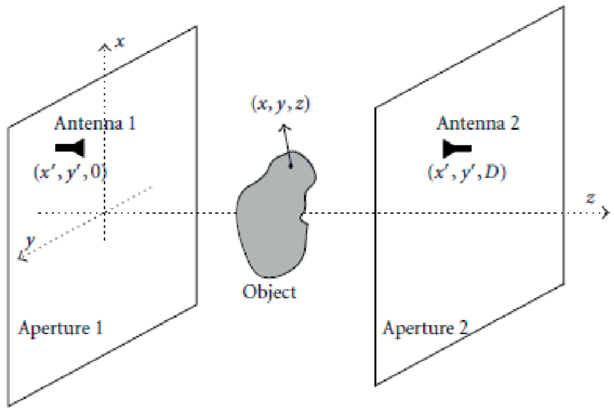

Figure 8: Arrangement of Antenna and Object for Inverse Image Reconstruction

Source: RAVAN, M.; ANMINEH, R. K.; NIKOLOVA, N. K.; Two Dimensional Near Field Microwave Holography. Inverse Problems, v., 26, p. 055011-055032, 2010.

By adding some processing in holographic algorithms the non-point-wise antenna' function can be calculated by using inverse procedure of image reconstruction. The figure above, shows the antenna positions with different configuration partner. This principle working only the narrow range and recreate 2D image of object to predetermined in simulations. The unwanted signals also study. The next step of the present research project is to make the microwave imaging system by fabricating flexible antennas and test in the laboratory. Another thing parallel to this is development of an imaging algorithm as mention in the above section.

CONCLUSION: Microwave imaging technique is non-invasive in nature which is can be used to diagnose and reveal the internal biological structure of the targeted object like breast in our case. The importance of these principles is still be determined but the issues in these method to interaction the electromagnetic radiation in vivo drives on large scale in research group. Breast cancer has become the most threatening disease the woman and this is most common type of tumor in women and a major cause of female mortality, the major concept to enhance the efficiency of the early tumor detection. Some major limitations of x-ray mammography are even it's the only official technique to locate the tumor,

- Lake of early-stage detection;
- Limitation over the age group;
- Dense Breast;
- Yearly Screening of Patient;
- High Rate of false-positive and false-negative Results;
- Painful;
- Expensive for a common person;

Those limitations forced to develop some new technique which can help to diagnose the breast cancer. These are the main features to follow for the development of new technology for breast screening. Microwave Breast Cancer Imaging is a technique which is cost effective and more precise in results. Early stage detection of breast cancer is possible with MWI which reduce the death rate due to breast cancer. Non-ionizing nature of this technique allows yearly screen as recommended by American and Canadian cancer society. The totally focus in this method on dielectric properties of cancerous and normal breast cells in microwave frequency range. MWI is working on the interaction of electromagnetic radiations with tissues. The diseased tissues have a high concentration of water therefore; the scattered radiations have strong signals to generate a clear image using different mathematical algorithms. MWI is a cost effective, more efficient and user-friendly technique but it's still under developing.

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