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A PILOT STUDY ON THE USE OF ELECTRICAL BIOIMPEDANCE SYSTEM AS A PRIMARY METHOD FOR BREAST CANCER SCREENING

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Abstract— **Electrical Bio-impedance Tomography (EBT) is a homemade non-invasive system designed to image breasts in the geometry of mammogram through applying an alternating-current (AC) and measuring the voltage distribution that result, and using computational methods to reconstruct an image of the breast conductivity that corresponds to breast pathology. In this study, 126 patients were examined with EBT and compared these images to X-ray Mammography (MG). Using the visual criterion, the sensitivity of EBT in diagnosing different breast pathology was found to be less sensitive compared to mammography with no significant difference. EBT could be used as an adjunct to MG for breast cancer screening.**

Keywords—**Electrical Bioimpedance Tomography, X-ray Mammography, Breast electrical conductivity, Breast tissue classification**

I. INTRODUCTION

Breast cancer is one of the most frequently diagnosed cancer in females worldwide and the rates are increasing [1] and it is largely attributed to aging of the population [2]. The breast cancer accounts for 30-40% of all the cancers in women all over the world [3]. According to World Health Organization, more than 30% of cancer deaths can be prevented [4]. In general, the earlier the cancer is detected and treated, the better the chance for survival [5]. There are two methods for detection of malignancies of breast: first self-observation of early signs of cancer and tumors and seeking prompt medical attention, second screening programs campaigns to detect early cancer or pre-cancer stage before signs recognition [6]. In the past recent years, mortality has been decreased significantly due to screening by medical imaging modalities [7]. At present, X-ray mammography is the gold standard modality for breast cancer detection and screening [8], although mammography has high sensitivity and specificity within the fatty breast and in the detection of microcalcifications, it has some multiple shortcomings according to the Breast Cancer Detection Demonstration Project (BCDDP) [9, 10], mammography is particularly defenseless at missing malignancies in more youthful ladies with denser breast tissue. After 10 sessions, a woman has a

cumulative probability of 49.1% of undergoing an unnecessary biopsy, and 70-80% of the women who undergo biopsies due to their mammographic findings have benign lesions. Since mammography cause cumulative x-ray exposure and it is hard to use with dense breast tissue (noticeable in more younger ladies), mammography is fundamentally prescribed for women over age 40 years of age [11]. Numerous ladies evade mammograms since they discover the breast pressure awkward and in certain cases painful. Mammography has a high number of false positive results, many women must undergo the psychological trauma, physical scarring, and financial hardship of unnecessary biopsies [12]. Instead of using X-rays to detect malignancies, another possibility is to use electricity to accomplish the same goal. Consequently, the new technology electrical bioimpedance tomography (EBT) which is a relatively new imaging method that has evolved over the past 20 years is recommended by Hope et al. (2004), which is a noninvasive procedure using electrical bioimpedance to image the human breast [13]. This scanning device is portable and does not emit any ionizing radiation thus it can be done on pregnant women by means of no age limit and not expensive [14]. The value of EBT technique is based on the variation of electrical storage potential values for both normal and pathological tissues. These variations allow to construct an image of conductivity and permittivity of the breast tissue. Previous experimental studies with EBT have shown that significant changes occur in the electrical properties of breast cancer tissue compared to the surrounding normal tissue [15, 16]. Some evidence has been found that malignant breast tumours have lower electrical impedance than surrounding normal tissues [15, 16]. This observation has led to the proposal that electrical bioimpedance could be used as an indicator for breast cancer detection [19, 20, 21]. Using EBT system, is radiation free, and since it is portable, the screening can be done virtually anywhere. No materials like gel or ECG spray are required for scanning procedure. The research goal of this paper is to study the capability of the use of EBT as a dependable technique for breast cancer screening and diagnosis in comparing to X-ray mammography [22].

II. EXPERIMENTAL METHOD

A. EBT System Overview –

This device consists of an array of 64 stainless steel electrodes (8x8) array with 10 mm diameter spaced by 5 mm fabricated on a printed circuit board and embedded in a Plexiglas plate, Figure [1] and uses small electrical pulses (0.4 mA, 125 kHz) for the breast examination. These electrodes array connected to the main unit which consists of multi frequency alternating current (AC) voltage source, Microcontroller, Multiplexers, Analog to Digital Converter (ADC), divider circuit, peak detector system, and computer for running software, A schematic diagram for EBT system is shown in Figure [2]. The procedure continues for each electrode, measurements are taken within 30 seconds. The received data is reconstructed into a tomographic conductivity images of the breast that analyzed and diagnosed for each patient and compared to the corresponding X-ray mammographic images for the same patient Figure [3].



Fig. 3. X-ray Mammographic machine in adjacent to EBT system



Fig. 1. Plexiglas plate containing embedded 64 electrodes for breast tissue electrical bioimpedance measurements

B. Breast Examination –

In this study a total of 126 patients presenting with various breast complaints with confirmed diagnosis, 54 of them were normal cases, 24 were benign tumor cases, and 48 were cancer cases. All patients were examined using X-ray mammography (MG), and Electrical Bioimpedance Tomography (EBT) system. All the imaging procedures done at Department of Radiology, Medical Research Institute, Alexandria University, Egypt. after all the volunteers completed the necessary consent forms.

III. RESULT AND DISCUSSION

The study was conducted to determine the diagnostic efficiency of Electrical bioimpedance Tomography (EBT) system as compared to X-ray Mammography (MG) in imaging the breast as shown in Figure [4], an example case for the images of both MG and EBT in cranio-caudal position for right breast of 47-year old woman and has BMI 23.2 Kg/m². This patient was diagnosed as normal case using the visual criterion, since no inhomogeneities were observed. Another example case in shown in Figure [5] the images for left breast of 56-year old woman and has BMI 23 Kg/m², this patient was diagnosed as abnormal case using the visual criterion, since the marked area refer to central breast mass surrounded by tissue infiltration.

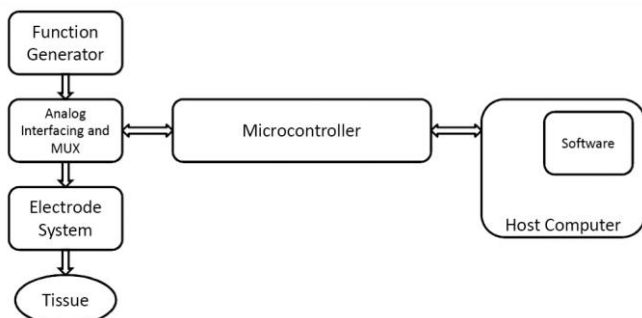


Fig. 2. A schematic diagram for EBT system hardware.

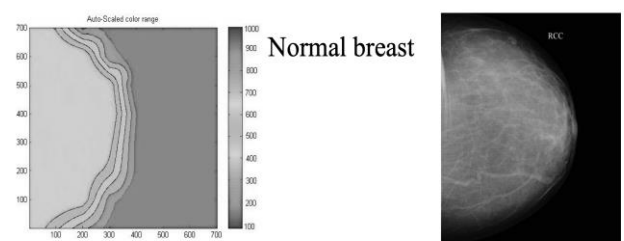


Fig. 4. Images of EBT (left) compared to MG (right) for the same patient diagnosed as normal case.

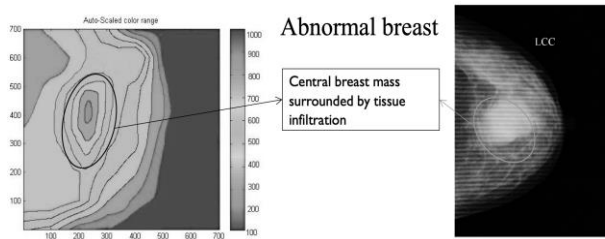


Fig. 5. Images of EBT (left) compared to MG (right) for the same patient diagnosed as abnormal case.

The sensitivity of EBT in diagnosing different breast pathology was found to be less sensitive compared to mammography. Details of the sensitivity analysis are shown in Table 1. The results of study showed that, no significant difference in sensitivity between mammography and EBT ($p=0.696$).

Table -1 Comparative sensitivity results for MG and EBT

Diagnosis	No. of Cases	Sensitivity	
		X-ray Mammography	Electrical Bioimpedance
Normal	54	74%	76.3%
Benign	24	86.4	73.2
Malignant	48	98.8%	81.6%

In 2012, Raneta et al. (2012) conducted a study among 808 patients on women from Slovakia found that the sensitivity of EBT was 87%, lower than MG (89%), but these differences is insignificant. The findings of this study showed that, in combinations EIT + MG sensitivity increased to 96% [23].

Zain et al. (2014) [24] did one study among 150 symptomatic women underwent EBT examination in Department of Radiology, University of Kebangsaan Malaysia Medical Center, Malaysia. Results of this study showed EBT had 64.4% of sensitivity using diagnostic (MG).

IV. CONCLUSION

With EBT imaging, there two most important factors that affect EBT sensitivity, careful electrode plate positioning and the patient's remaining motionless during imaging procedure.

In conclusion, based on the results of this study and the obtained from previous studies related to sensitivity of EBT and comparing with MG; it appropriate to use EBT for preventive check-ups of the female population between rounds of screening in order to isolate patients at risk; in examination of pregnant and lactating women and with younger age women as well as women with high risk factors of cancer and as an additional method.

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