# Measurement of Ultrasound Attenuation for Normal and Pathological Mice Breast Tissue using 10MHz Ultrasound wave.

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*Abstract:* - A new hybrid method that is based on the interaction of ultrasound and magnetic field has been developed for breast tumor detection. This method is capable to assess the acoustic and electric properties of normal and pathological breast tissue for characterization. In this study, the acoustic attenuation of normal and pathological mice breast tissue has been investigated from the ultrasound signal that is captured and recorded by the hybrid magnetoacoustic system. A total of 8 normal and 10 pathological mice breast tissue samples were studied by using a 10MHz ultrasound wave in transmission mode. The result of the attenuation measurement shows that pathological tissues attenuate more ultrasound compared to normal tissue. These results also agrees very well with previous research finding that indicates attenuation is lower for tissue with high proportion of cells such as mammary gland and fatty tissue and increases with collagen fibre content since the pathological tissue that were used in this study is multifocal, highly fibrotic and involve the entire mammary fat pad.

*Key-Words: - Hybrid magnetoacoustic, 1D ultrasound, attenuation, normal and pathological, breast tissue.*

## 1 Introduction

### 1.1 Hybrid Magnetoacoustic Method.

Hybrid magnetoacoustic is a new breast cancer detection method that manipulates the interaction between acoustic and magnetic energy on random ionic particles inside a tissue. Biological tissue is a conductive element due to the presence of random charges that is mainly contributed by intra and extracellular diffusion that supports cell metabolism [1-6]. Propagation of ultrasound wave will cause charges inside the breast tissue to move at high velocity due to the back and forth motion of the wave [6-8]. Moving charges in the present of magnetic field will experience Lorentz Force. This force separates the positive and negative charges, producing an externally detectable voltage that can be collected using a couple of skin electrode [1-3].
This interaction has been manipulated to map conductivity data of biological tissue especially in impedance imaging. However, previous researches [1-8] apply magnetoacoustic method for conductivity mapping purposes only. The ultrasound wave that is used to stimulate ionic particle motion is not taken into account though its output delivers valuable information with regards to tissue mechanical properties [9]. Acoustic property such as attenuation has been proof so far to be very valuable in characterizing different biological tissues [10-14,17] and materials [18]. Hence, this paper presents ultrasound attenuation measurement from normal and pathological mice breast tissue for characterization purposes recorded by the system.

### 1.2 Ultrasound attenuation

The attenuation of ultrasound wave that passed through tissues is unique and frequency dependant [10]. Previous study shows that ultrasound attenuation has a very high potential in characterizing biological tissue [17]. In the field of breast cancer study, specific normal and abnormal breast tissues such as fatty tissue, medullary carcinoma, infiltrative lobular carcinoma, fibrocystic and fibro fatty tissue have been characterized in [10,17] using ultrasound wave ranging below 10MHz by considering its attenuation coefficient. The same study were also done [15,16] to discriminate benign and malignant breast tissue by accessing the tumor backscatter echo, speed of sound and attenuation coefficient. However, the type of benign and malignant tissue used in these studies is not stated specifically. In [16], discrimination has been done by comparing their frequency dependant attenuation and speed of sound of ultrasound wave ranging from 2 to 9MHz.

# 2 Materials and Method

## 2.1 Mice Strain

The used of animal in this study is approved by the National University of Malaysia Animal Ethics Committee. 2 sets of mice strain FVB/N-Tg MMTV PyVT 634 Mul and its control strain FVB/N is obtained from the Jackson Laboratory, USA.

For the transgenic mice set, hemizygote male mice were crossed to female noncarrier to produce 50% offspring carrying the PyVT transgene. The Mice offsprings were palpated every 3 days starting from 12 weeks of age to identify tumors in which earliest tumor development starts at 5 weeks of age. Adenocarcinoma that arises in virgin and breeder females were observed to be multifocal, highly fibrotic and involve the entire mammary fat pad [19]. Mice carrying the PyVT transgene also show loss of lactational ability since the first pregnancy [19].

In this study, 8 normal and 10 pathological breast tissue specimens were harvested from 4 normal and 5 transgenic virgin, female mice at the age of 18 weeks.

## 2.2 Mice Anesthesia and Surgery

Individual mouse was restrained by using a plastic restrainer before anesthesia. Anesthesia was performed by using the Ketamin-Xylazil-Zoletil cocktail dilution. 0.2ml of the anesthetic drug was administered intravenously from the mouse tail and an additional of 2ml of anesthetic drug was delivered intraperitoneally for about 2 hours sleeping time. Fur around the breast area was shaved. Normal and pathological mammary tissue were harvested from the mice while they were sleeping. Mice were then killed by using drug overdose method. Before the specimens were cut into the required shape and thickness, their physical appearance was first observed.

## 2.3 Ultrasonic Analysis

Excised breast specimens were cut down to an approximately 1cm x 1cm square shape with thickness of 1mm immediately after the surgery [10]. Part of the specimens was immersed in buffered formalin for Histological examination. The specimens were immersed in gel that is located between the ultrasound transmitter and receiver. Ultrasound analysis was started and performed at a constant temperature of 21°C by using the insertion loss method described elsewhere previously [10-14]. In the Insertion loss method, attenuation of ultrasound travelling through the tissue immersed in the gel was deducted by the attenuation of ultrasound propagated through the gel when tissue was removed.

The hybrid magnetoacoustic system recorded the ultrasound signal in time domain. Signal is captured by using a frequency sampling of 2.5GHz. All signals were first filtered by using the 2$^{nd}$ order Low Pass Chebyshev filter to remove the unwanted signal over 50 MHz. The signals were then converted to frequency domain for analysis. Squared spectrum of the signal was calculated in Matlab. Attenuation coefficient in dB is calculated as [18, 20]:

$$\text{Attenuation: } 20 \log_{10}[I_t/I_g] \quad (1)$$

Where $\log_{10}I_t$ is the squared spectrum of the ultrasound signal propagating through gel with tissue and $\log_{10}I_g$ is the square spectrum of the ultrasound signal propagating in gel without tissue.

# 3 Result and Discussion

## 3.1 Tissue Appearance

Fig 1: Physical appearance of a pathological breast masses from an individual mouse subject.

Fig 2: Physical appearance of a normal breast masses from four individual mouse subjects.

### 3.2 Ultrasound Analysis result.

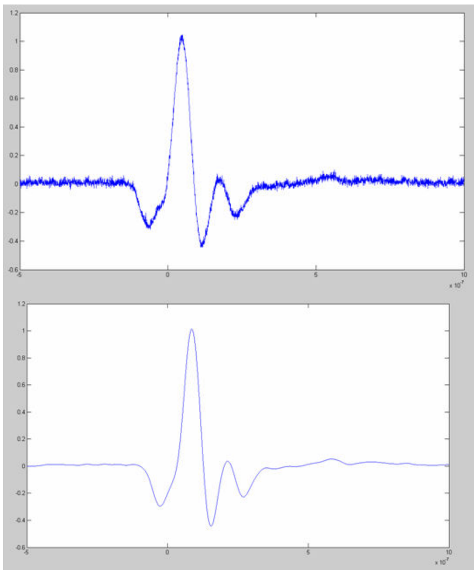

Fig. 3: Original ultrasound signal recorded by the system and its corresponding filtered signal

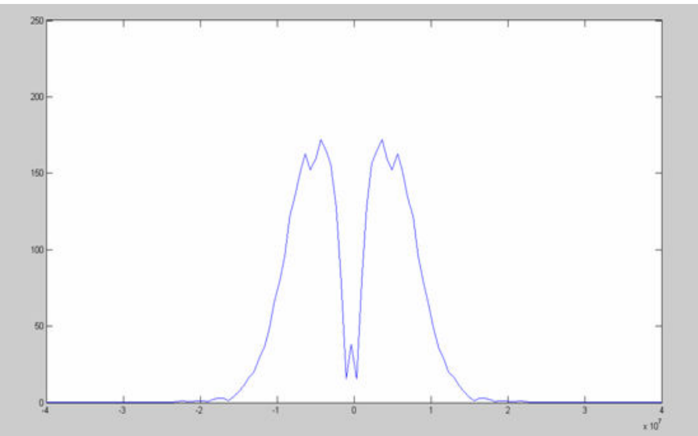


Fig. 4: FFT of the ultrasound signal calculated in Matlab

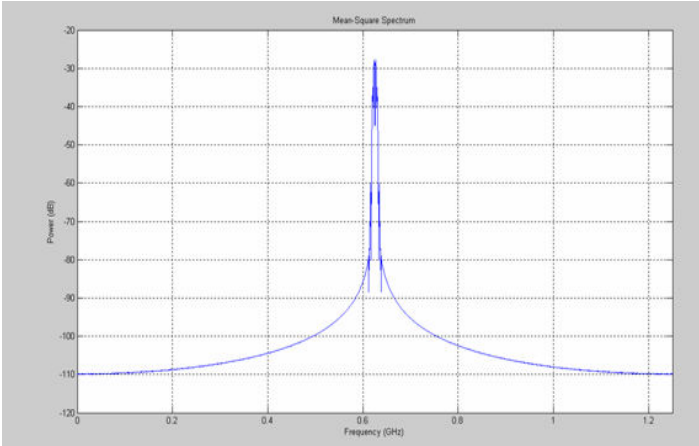


Fig. 5: Mean Squared Spectrum of the filtered ultrasound signal

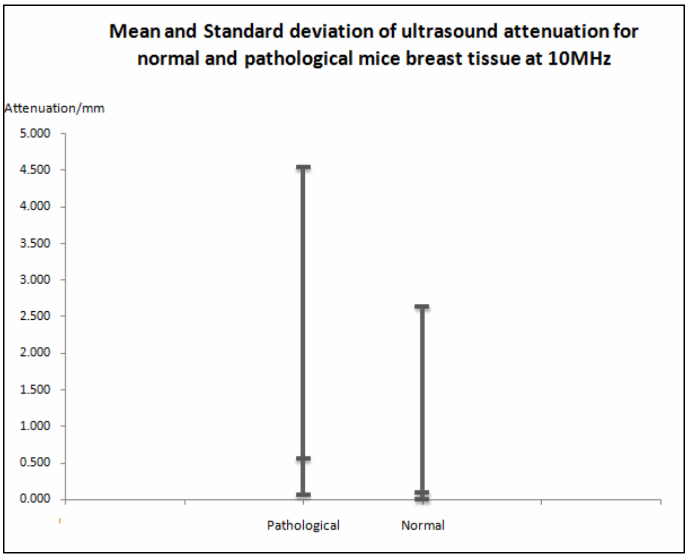


Fig. 6: Mean and standard deviation of ultrasound attenuation for normal and pathological mice breast tissue at 10MHz.

Figure 3, 4 and 5 shows the signal processing steps to determine the attenuation value of the breast tissue specimens. Final attenuation value was calculated by substituting the peak mean squared spectrum of the signals into equation (1). The result in Fig. 6 shows the mean attenuation for these tissues permilimeter at 10MHz. The mean result shows that pathological tissue attenuates more ultrasound compared to normal tissue at the same propagation distance. These results also agrees very well with previous research finding [17] that indicates attenuation is lower for tissue with high proportion of cells such as mammary gland and fatty tissue and increases with collagen fiber content since the pathological tissue that were used in this study is multifocal, highly fibrotic and involve the entire mammary fat pad [19].

However, this result contradicts with our previous simulation result on the attenuation of normal and

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pathological breast. The simulation was calculated based on attenuation coefficient in [20], in which the attenuation of normal tissue is higher than the pathological tissue.

## 4 Conclusion

A new hybrid method that capable to measure acoustic and electric properties of tissues has been developed for breast cancer detection. The present paper reports on the measurement of acoustic property of tissue namely acoustic attenuation. 8 normal and 10 pathological mice breast tissues specimens have been studied by using the insertion loss method. Result shows that pathological tissues attenuate more ultrasound compared to normal tissue as attenuation is low in tissue with high proportion of cells and increasing with collagen content.

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