Contribution ID: **55** Type: **Poster**

Measurement of the speed of sound, attenuation and mass density of fresh breast tissue

Thursday, November 2, 2017 3:00 PM (1 hour)

An improved distinction between benign and malignant lesions is necessary to enhance the diagnostic value of breast ultrasonography. This requires a better quantitative characterization of tissues and hence accurate knowledge about the acoustic medium parameters. Current data on these parameters is inconsistent due to variations in applied measurement protocols. We tested a standardized protocol for measuring the speed of sound, attenuation and mass density of freshly excised breast tissues.

(4) Discussion and Conclusion

It is shown that protocols affect the results. To measure the parameters, it is recommended 1) to use only fresh samples and perform the measurements at 37°C, 2) to avoid sample holders that deform samples, 3) to minimize submersion time to reduce absorption effects, 4) to measure properties at each location separately and 5) to use thin and smooth samples. Results suggest that PBS is not suitable as a reference medium for measuring the density and that formalin may be an alternative.

(2) Material and Methods

Three patients scheduled for a mastectomy, were included in the study. Tissues of skin, nipple, intra-glandular fat, glandular tissue and breast carcinoma were analysed. Two experimental methods were developed. The first uses pulse-echo measurements to measure the speed of sound and frequency dependent attenuation; the second uses a pycnometer to measure the mass density. Two important adjustments were made to mimic in vivo conditions. First, a novel sample holder using a vacuum pump was developed. This has the advantage that the sample thickness could be obtained at each grid point separately without compressing the tissue. Second, physiological phosphate-buffered saline (PBS) solution of $37^o\ C$ was used to prevent absorbing.

(3) Results

For fresh samples of fat, skin, glandular tissue and nipple, the following values are found for the sound speed: 1456 m/s, 1559 m/s, 1564 m/s and 1574 m/s; frequency dependent attenuation: 5.7 Np/m $\text{MHz}^{-1.3}$, 4.8 Np/m $\text{MHz}^{-1.7}$, 10.5 Np/m $\text{MHz}^{-1.5}$ and 4.6 Np/m $\text{MHz}^{-2.0}$; and mass density: 869 kg/m^3, 970 kg/m^3, 874 kg/m^3, 987 kg/m^3, respectively. Significant differences are observed when comparing the results with literature, see Fig. 1.

For density, higher values are found when using larger samples, see Fig. 1. An increase is seen for samples that are measured before and after being submerged in PBS. On the contrary, similar values are found for samples that are fresh, cooled, or submerged in formalin.

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Session Classification: Poster session

Track Classification: Main Track