Electrical Impedance Spectroscopy: Preliminary Experiments Imaging Human Breasts

We imaged the breasts of 12 women to investigating the feasibility of routine EIS exams with a system we built. We simultaneously applied spatially varying voltages (1Vpeak, 10kHz to 1MHz) through 16 Ag/AgCl surface electrodes equally spaced on a radially translating apparatus. The magnitude and phase of the resulting currents were digitized. Using the measured currents as the boundary conditions, we numerically solved the complex Laplace equation to produce spatial plots of absolute electrical conductivity and permittivity. Imaging experiments consisted of acquiring data at 10 frequencies on both breasts. Participants lay down prone on an examination table with one breast positioned in an electrode array. Exams easily performed and well tolerated, lasting about 10 minutes per breast. The resulting images seem to be quite sensitive but not specific to pathology. For example, of the 3 cases with known tumors, we saw "abnormal" images in all 3 cases, but we could not definitely distinguish these from other abnormalities. While localized near-surface electrode artifacts have been evident, several findings have emerged. The normal mammogram breast appears to have a characteristic EIS permittivity image emerging across subjects. Structural features in the EIS images have generally correlated with tumors, cysts, scarring from recent lumpectomy and follow-up radiation therapy. We can detect lesions on the order of 1 cm but cannot always precisely locate them. With improved calibration and electrode artifact modeled compensation, we hope to distinguish specific lesions by their absolute conductivity & permittivity values.