# ULTRASOUND STRAIN AND ATTENUATION IMAGING FOR DETECTION OF UTERINE MASSES

Eenas Abdalla Omari

Under the supervision of Professor Tomy Varghese

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Abnormal uterine bleeding is one of the most common symptoms patients present within the gynecology unit, whether they are post-menopausal or pre-menopausal. Some of the major causes of dysfunctional uterine bleeding are benign masses or ingrowths such as leiomyomas (fibroids), endometrial polyps, and adenomyosis. Other causes are malignant such as endometrial cancer, also known as uterine cancer. It is important to have an accurate diagnosis of the type of uterine masses that cause abnormal uterine bleeding since clinical treatment and management differ substantially. Ultrasound elastography and attenuation imaging are envisioned as optional modalities to augment standard ultrasound B-mode imaging.

Palpation has been used for centuries to determine stiffness variation in tissue. Since different uterine masses and tissue possess significant variations in stiffness, ultrasound strain imaging can potentially be useful in the detection of such masses. We demonstrate the feasibility of a novel approach to strain imaging of the uterus by combining an often used ultrasound examination, i.e., saline infused sonohysterography that is used to detect polyps and other ingrowths, with data acquisition for ultrasound strain imaging. Strain images were estimated using a two-dimensional multilevel hybrid algorithm developed for ultrasound sector array

transducers. Coarse displacements are initially estimated using envelope echo signals. This is followed by a guided, finer displacement estimation using window lengths on the order of 6 wavelengths and 7 A-lines on radiofrequency data. Strain images are obtained by estimating displacement slopes using least squares estimation. We show that stiffer masses such as fibroids appear darker or as regions with low strain on strain images. A high strain boundary around some stiff masses, referred to as a 'halo,' is believed to be caused by increased slipping or sliding of the mass during the applied deformation. Uterine polyps on the other hand are visualized as masses that have a thick bright boundary surrounding the polyp, or regions exhibiting higher strain. This is an indication of a softer mass. Mechanical testing to establish the elastic contrast between normal uterine tissue and stiffer masses such as leiomyomas (uterine fibroids) and between softer pathologies such as uterine cancer and adenomyosis demonstrate the viability of ultrasound based strain imaging.

Quantification of viscoelastic characteristics of uterine tissue and associated pathologies globally and locally is presented. Tissue samples were dynamically and quasi-statically tested, and the results obtained with both methods are comparable. We also characterize tissue stiffness variations locally using a nano-indenter, where the results demonstrate that some regions exhibit higher or lower stiffness values when compared to the normal tissue modulus estimated, which could indicate the presence of pathological tissue.

Attenuation estimation can also be used to quantify underlying tissue pathology. We report on the accuracy and precision of three frequency domain estimation methods, namely the reference phantom method, a centroid downshift method and a hybrid method. The impact of sound speed and backscatter intensity variations for the different estimation approaches are evaluated. The reference phantom method provided accurate results when the acoustical properties of the reference and sample are well matched. Underestimation occurs when the reference phantom possessed a higher sound speed than the sample, and overestimation when the reference phantom had a lower sound speed than the sample. The centroid downshift method depends significantly on the bandwidth of the power spectrum, which in turn depends on the frequency dependence of the backscatter coefficient. A hybrid method was the least susceptible to changes in the sample’s acoustic properties and provided the lowest standard deviation in numerical simulations and experimental evaluations. Attenuation images of the uterus using radiofrequency data acquired during saline infused sonohysterography procedures provide interesting contrast with B-modes images of the same tissue.