

Purpose: Manual palpation is often used to qualitatively assess the presence of diseases because of known correlations between tissue stiffness and pathological state. Ultrasound elastographic techniques provide an objective form of palpation and include strain imaging, acoustic radiation force imaging (ARFI), and transient elastography. However, tissue compression can affect tissue stiffness estimates. In this study, we dynamically compress several different hepatic malignancies through a range of compressional loads to determine the effect of strain hardening on modulus estimates and modulus contrast.

Methods: Fourteen hepatic tissue samples with various pathologies were obtained from the UW Pathology lab from patients undergoing surgical resection. Among them were hepatocellular carcinomas (HCCs; n=2), colon metastases (METs; n=7), rectal METs (n=1), gastrointestinal (GIST) METs (n=1), neuroendocrine METs (n=1), and cirrhosis (n=2). Samples were dynamically tested using an Enduratec ELF 3220 (Bose Corp., Minnetonka, MN) from 1 to 6% precompression at 1, 10, 20, and 30 Hz.

Results: The storage modulus, a measure of the elastic energy stored each compression cycle, was quantified for pathological and normal tissue. The average storage modulus for normal tissue tested at 1% compression and 1 Hz was 3.3 kPa. The storage moduli for pathological tissue were 3.5, 23.1, 30.9, 4.3, 3.9, and 13.7 kPa for HCCs, colon METs, rectal METs, GIST METs, neuroendocrine METs, and cirrhosis, respectively.

Conclusions: These results show the effects of strain hardening on normal and pathological human liver tissue. Some cancers were significantly stiffer than the surrounding background, indicating that elastographic techniques may be useful in delineating the pathology. Some cancers, such as HCCs, were approximately the same stiffness as the surrounding background. Strain hardening observed with some cancers suggests that compression may increase contrast between the cancer and the surrounding tissue.

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