Histological Analysis of Biological Tissues using High-Frequency Ultrasound

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Abstract

- High-frequency (HF) ultrasound can differentiate between a range of breast pathologies in surgical specimens.
- Two parameters sensitive to histopathology.
- Real-time measurements may assist surgeons in obtaining negative or cancer-free margins during lumpectomy to eliminate invasive re-excision.

Objective

- Determine the mechanism linking HF ultrasound to histology.
- Review breast specimen results.
- Test range of bovine tissue from heart, kidney, and liver.
- Related study: Multivariate analysis of the parameters permitted differentiation of normal, adipose, liver, and lymph nodes.

Hypothesis

- Ultrasound sensitivity is a function of the microscopic heterogeneity (and thus histology) of the tissue.

Ultrasonic System

- High-resolution, b-scan images of normal breast tissue.
- Dynamic range of 20 MHz.

Waveform Analysis

- Through-transmission and pulse-echo images.
- First-and second-order spectra.

Surgical Margin Results

- Benign vs. malignant.
- Ductal carcinoma in situ (DCIS).
- Lobular carcinoma in situ (LCIS).
- Invasive ductal carcinoma
- Invasive lobular carcinoma

Multivariate Analysis

- Multivariate analysis of the parameters permitted differentiation of normal, adipose, liver, and lymph nodes.
- Bovine kidney: Vascular tissue.
- Bovine heart: Vascular tissue.
- Human breast: DC, LC.

Discussion

- Repeatability correlations between tissue heterogeneity, peak density of 1st-order spectra:
  - Human breast: DC, LC.
  - Bovine heart: Vascular tissue.
  - Bovine kidney: Ureter, stroma.

Conclusions

- HF ultrasound is sensitive to microscopic heterogeneity and (thus histology) in tissues.
- Tissues with greater peak densities in 1st-order spectra:
  - Exhibit complex, less uniform histology.
- Tissues with lower slopes in 2nd-order spectra:
  - Exhibit normal ductal structure.
  - Normal breast glands, renal medulla.

Applications

- Intraoperative evaluation of margins during breast cancer surgery.
- Real-time pathology for cancer procedures.

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