Microwave-Related Tissue Changes Using Ultrasound: Processing Images into Spectral Colors (08-ENBM-0034)

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Abstract

Microwaves in the medical field are used to denature proteins and deactivate abnormal cells. Ultrasound helps define organ structures and identify abnormalities. In my previous study, increased duration of exposure of tissue to microwaves was associated with statistically significant increase in intensity of brightness of the images. Ultrasound images are monochromatic which results in underappreciation of the subtle changes in the brightness of tissue by the naked eye. By increasing the variations in spectral colors of the brightness of the reflected ultrasound waves, it may be possible to recognize the changes and help apply them in clinical practice. This study seeks to advance the knowledge of reflected waves by processing ultrasound images to spectral colors for recognizing tissue changes with microwave exposure. Ultrasound images of lamb muscular, lamb liver, and chicken muscular tissue before and after exposure to microwaves were studied. A total of 30 organic tissue images were studied. Although this was a statistically significant increase in brightness of a scale of the studied tissue images to exposures to microwaves energy (chicken muscle 41.18% vs 71.77%, Lamb liver 32.70% vs 65.18%; Lamb muscle 54.04% vs 70.90%), the changes on monochromatic images were not well appreciated. Using an algorithm to represent the images in spectral colors (altering the intensity of brightness into RGB value of a color) resulted in better appreciation of the changes. The finding of the study could possibly be helpful in real time appreciation changes in tissue exposed to microwave energy in clinical practice.

Materials & Methods

- 15 pieces of tissue (5 each of Chicken Muscle, 5 Lamb Liver, and Lamb Muscle) were obtained from the local store over 2 cm in thickness (as measured in raw status).
- 3.5 MHz 2D M-Mode Ultrasound
- Conventional Knives
- Ultrasound
- Small container
- Water
- Paint App (Windows 10)
- C++ IDE versions 3.11.2

Introduction/Research

- Microwaves
  - Electromagnetic radiation with wavelengths ranging from about one meter to one millimeter
  - Frequencies between 300 MHz and 300 GHz
- Microwaves vs ultrasound
  - Microwaves work by using microwave about 12 centimeters in length to force water and fat molecules in food to rotate quickly
  - Interaction of these molecules underlying forced rotation creates heat, and the food is cooked.
- Ultrasound
  - Heating organic tissue causes aggregation of protein structures identified in the form of increased opacification and shrinking of the tissue on gross examination.
- Medical applications of microwaves
  - Rapidly developing field
  - Results in destruction of malignant/abnormal cells by rapidly increased temperature resulting in loss of self-protective mechanism of abnormal cells
- Extent of destruction of abnormal tissue is essential for
  - Accomplishing successful therapy
  - Reducing collateral damage
- Ultrasound
  - Sound waves with frequencies higher than the upper audible limit of human hearing (over 20kHz).
  - Share physical properties of "normal" (audible) sound.
  - Reflected waves in the form of echoing of the sound.
  - The reflected waves have information of distance and also signal of the object it bounced against (brightness).
- Ultrasound in medical field
  - To identify organ structures in the body (McMahon).
  - In my previous study, I found that:
    - Increasing exposure to microwave ↔ Increased intensity of reflected ultrasound waves.
    - Although this was statistically significant, recognizing the changes on visual examination was not distinct.
  - Humans can distinguish about 30 different monochromatic shades.
  - Ultrasound scans are monochromatic.
  - Subtle changes might go unappreciated.
  - Computer programming may assist in these differences in brightness distinguishable.

Results

- Total of 30 ultrasound images studied
- Highest intensity: 80.39%; Lamb Muscle After Exposure
- Lowest intensity: 27.84%; Lamb Liver Before Exposure
- Most difference in reflected ultrasound waves was lamb muscle tissue (54.04% vs 70.90%)
- Intensity of reflected ultrasound waves increased after exposure to microwaves
- T-Test confirmed the significant increase in the intensity of reflected ultrasound waves in each of the tissue studied (chicken muscle 0.610, lamb liver 0.006, lamb muscle 0.007)
- Algorithm help represented monochromatic ultrasound scans into color images
- Intensity of ultrasound waves reflected in a pixel appropriately were replaced with a color on the electromagnetic spectrum
- Post processing images replicated the changes noted in monochromatic ultrasound scans
- Changes in intensity of reflected ultrasound waves were easily perceived by the naked eye

Discussion

- Pre- and Post-exposure images were easily distinguishable and could be accurately identified (farther randomized evaluation may be required)

Conclusion

- Intensity of brightness of tissue on ultrasound images increased with exposed to microwaves (similar to my previous study)
- Summary
  - Algorithm changed appropriately monochromatic ultrasound to color images
  - Intensity of ultrasound waves reflected in a pixel appropriately were replaced with a color on the electromagnetic spectrum
  - Post processing images replicated the changes noted in monochromatic ultrasound scans
  - Changes in intensity of reflected ultrasound waves were easily perceived by the naked eye
- Each individual pixel’s RGB value of the image was converted to the percentage of ultrasound waves brightness and represented in visible light wavelength, a new RGB value (R’G’B’).
- Scope
  - This program can be utilized in microwave-related ablations for visualization of the lesions created in real-time.
- Additional Notes
  - Further studies are required to assess the program’s use in real-time in-vivo procedures.

Bibliography