Phantom for Microwave Ablation Device Testing

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1. Abstract

Microwave ablation is a cutting-edge process by which microwaves are emitted through thin antennas positioned in tumors to generate temperatures high enough to destroy cancer cells. Our team designed and tested an innovative phantom for microwave ablation device testing.

2. Background Information

- Microwave ablation: medical treatment for abdominal cancers
- Thin antennas positioned in tumors
- Microwaves rapidly heat, causing cell death
- Testing: abdominal livers (expensive, short shelf life—necessitates improvement in testing methods)
- Phantoms: egg white, albumin
- Phantoms are homogenous
- Improved testing methods desired

3. Design Specifications

Important qualities of a liver phantom:
- Mimic qualities of liver
  - Dielectric properties: permittivity (45 ± 5 f/F/m), conductivity (1.7 ± 2 s/m)
  - Homogenous
  - Reproducible
  - Transparent
  - Clearly indicate ablation zone
- Able to withstand high temperatures from 160 to 180 °C without melting or deforming
- Reusable or easy to assemble
- Cost-effective (approximately $20 to $30)

4. Results

Final design: The final design is a mixture of egg white with added egg albumin; the ablation zone is clearly indicated by a clump of coagulated protein that can easily be measured. The dielectric properties are similar to the liver. The phantom costs less than $2.00.

5. Procedures

Experimental: Several samples were initially tested and tested for thermal property testing. Critical temperature, thermal stability, and indicating technique were initially assessed by testing the ablation temperature on a hot plate. The dielectric property testing was measured using the Agilent Technologies® E50701C ENA Series Network Analyzer and collected in the N3 LabVIEW.

6. Conclusion

- Phantom: egg white + egg albumin protein
  - Homogenous
  - Relatively transparent
  - Cost-effective
  - Clear ablation zone
  - Similar dielectric properties, ablation zone size, ablation temperature, and heat propagation as liver
  - Easy preparation

- The egg white albumin did not reduce the dielectric properties equally: the permittivity decreased more significantly than the conductivity.

- Dielectric properties contribute to the size of the ablation zone
  - Egg white + albumin has greater ablation zone size than just egg white
  - More protein to denature
  - More air in egg white which affects properties

- Temperature affects dielectric properties: higher temperature = lower permittivity & conductivity

7. Future works

- More repetitions of current methods
- Other methods for preparing sodium alginate, poly(vinyl alcohol) gels
- Try other proteins or combination to better match properties of liver
- Determine percentage of protein in phantom to validate consistent procedure

8. Acknowledgement

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9. References