Microwave Ablation with Tumor Permittivity Feedback Control: an Ablate & Resect Study in 10 Patients with Pulmonary Malignancies

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Disclosures

Damian E. Dupuy, MD
- MedWaves
  - Grant Support
Background

Pulmonary Tumor Ablation

- 20-25% patients with NSCLC present with localized disease
  - Stage I, II and IIIa → surgical resection
- RFA is a safe and valuable tx option
  - Most widely used ablative modality
  - Surgically unresectable
  - Medically inoperable
Background

- Advantages of microwave ablation
  - Hotter
  - Faster
  - Heat sink ↓
  - No grounding pads
Background

↑ Heat

↑ Kinetic Energy

→ Heat
Background

Applied Conditions → Dielectric Properties of Tissues → Physical Elements → Permittivity
Background

Tumor Permittivity Feedback Control

“Temperature Control” Mode

Power 10-32 Watts

Frequency 902-928 MHz
Background

Maximize energy deposition within tumor +

Minimize the reflectivity/reverse power

\[ \text{Hotter intra-tumoral temperatures} \]

with penetration

into surrounding aerated lung tissue

Oncologic resection margin (1cm)
Materials & Methods

Study Design

- Prospective study
  - Ablate and Resect Protocol
- IRB approved
- HIPPA compliant
- 10 consecutive patients at our institution
  - Inclusion Criteria
Materials & Methods

Patients

- Surgical resection of a biopsy-proven pulmonary malignancy
- Pre-operative staging CT and PET-CT
- Informed consent obtained prior to enrollment
Materials & Methods

Patients

- March 2009 – January 2010
- 10 patients (6 male, 4 female)
- Mean age 71 years (range, 52-82)
- Underwent intra-operative MWA of a resectable pulmonary malignancy
Materials & Methods

- **Endometrial**: 5 pts
- **Colorectal**: 3 pts
- **Mets**:
  - AdenoCa: 5 pts
  - SCC: 3 pts

Primary Disease
Materials & Methods

Tumors

- Mean maximum tumor diameter 2.4cm
  - range, 0.9-5.0cm
- Mean tumor volume 8.6cm$^3$
  - range, 0.4-53cm$^3$
Materials & Methods

Ablate & Resect Protocol

- Initial consultation
- Intra-Op
  - GETA
  - Thoracotomy with tumor exposure
  - Aeration of lung tissue via double-lumen ET
  - MWA and Air-leak testing
  - Standard Resection (wedge or lobectomy)
- Pathologic analysis
MWA Technique

- Straight, 14 Gauge, 4cm active tip MW antenna
Materials & Methods

MWA Antenna

- Cutting Tip
- Antenna
- Reflectivity and Temp Sensor
**MWA Technique**

**Tumor Permittivity Feedback Control**

- "Temperature Control Mode"
  - Power 10-32 Watts
    - Energy efficient design
  - Frequency 902-928 MHz
  - Target Temp 110-120 °C
- Single 10 minute ablation
Materials & Methods

Pathologic Analysis of Resected Specimens

- Gross inspection and sectioning
  - Maximum diameters
  - Prolate ellipse volumetric estimations
- H & E staining
- Cellular death confirmed with NADH assays
  - + staining = mitochondrial enzymatic activity, cellular viability
Results: Gross Analysis

Ablation Zone Characteristics:

- Ablation zone measurements
  - Grossly measurable in 5 resected specimens
  - Mean maximum diameter 4.8cm
    - (range, 3.0-6.5)
  - Mean volume 15.1cm³
    - (range, 7.3-25.1)
Results: Gross Analysis

Ablation Zone Characteristics

- Pleural retraction
Results: Gross Analysis

Ablation Zone Characteristics

- Hyperemic ellipsoid zone of coagulation necrosis

2.5cm, AdenoCa
Results: H & E Analysis

Ablation Zone Characteristics

H & E staining of all specimens

- Coagulation necrosis: Loss of cellular architecture
- No discernable membrane
- Amorphous cytoplasm
- Nuclear changes

2.5cm, AdenoCa
Results: H & E Analysis

Ablation Zone Characteristics

- Coagulation necrosis:

2.6cm, CRC Met
Results: H & E Analysis

Ablation Zone Characteristics

- Cytotoxic heating of peri-tumoral aerated pulmonary parenchyma

2.6cm, Endometrial Met
Results: NADH Analysis

Ablation Zone Characteristics

- NADH Staining Assays
  - 6 specimens
  - Confirming complete lack of viability
    - ablation zones
    - aerated pulmonary parenchyma
Results: NADH Analysis

1.0 cm, AdenoCa
Results: NADH Analysis

Ablation Zone Characteristics

- NADH Staining

2.3cm, AdenoCa

0.2cm
Results

Safety

- Intra-operative, post-ablation air leak
  - 1 Patient
- Post-operative mortality rate, 1% (1/10)
  - POD #5 s/p lobectomy
  - Progressive respiratory system failure
Results

Study Limitations

- Underestimation of ablation zone size
  - MWA $\rightarrow$ significant tissue contraction
    - Up to 52% in center of ablation zone
  - Measure contracted tissue
  - Falsely smaller ablation zone volumes
- Tissue friability $\rightarrow$ limited gross analysis
- Small cohort size

Conclusions

- Maximize the delivered MW energy
- Minimize the reflectivity/reverse power
- MWA Tumor Permitivitty Feedback Control resulted in:
  - Cytotoxic intra-tumoral temperatures
  - Extension of the ablation zone into aerated, peri-tumoral pulmonary tissue
    - Oncologic resection margin
Thank You