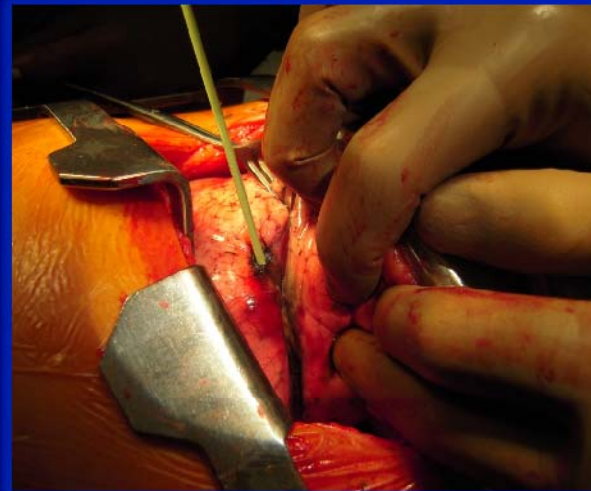


# Microwave Ablation with Tumor Permittivity Feedback Control: an Ablate & Resect Study in 10 Patients with Pulmonary Malignancies



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**BROWN**  
Alpert Medical School



# Disclosures

Damian E. Dupuy, MD

- MedWaves
  - Grant Support

# Background

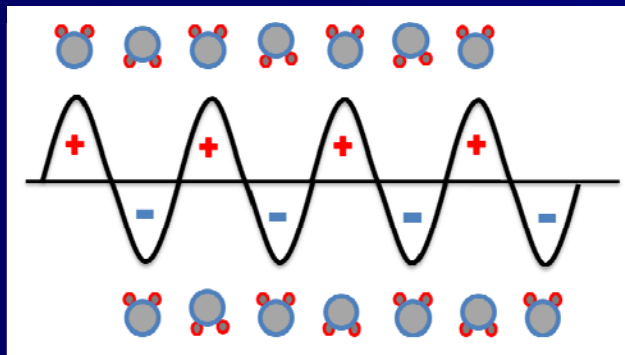
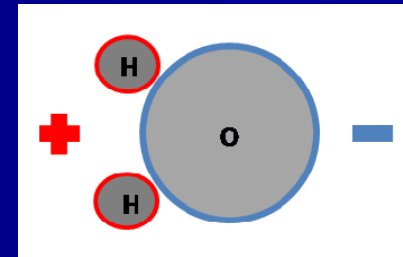
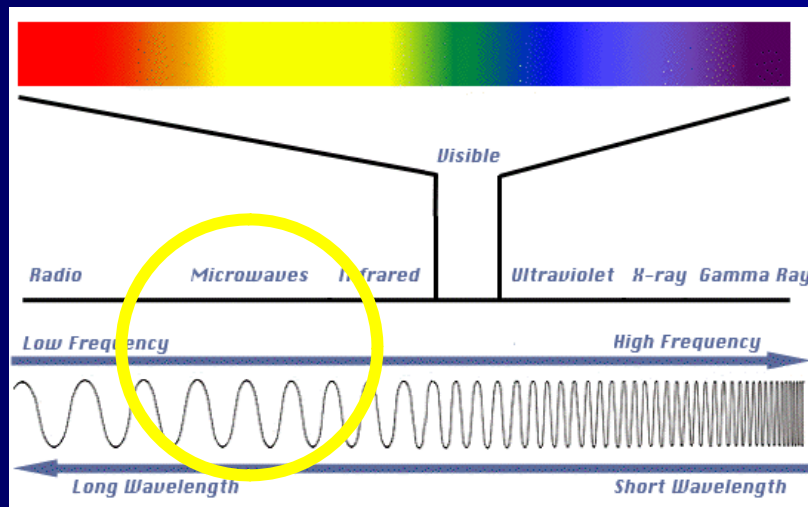
## Pulmonary Tumor Ablation

- 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



→ ↑ Kinetic Energy → **Heat**

# Background

Applied  
Conditions



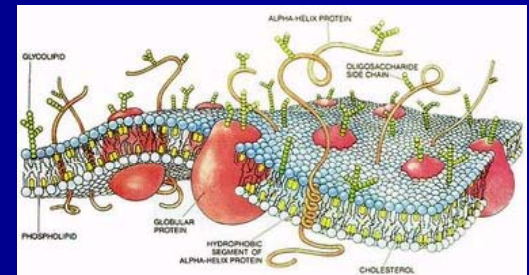
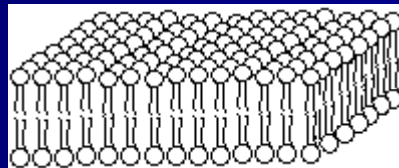
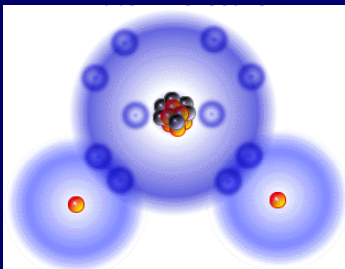
Dielectric  
Properties of  
Tissues



**Permittivity**

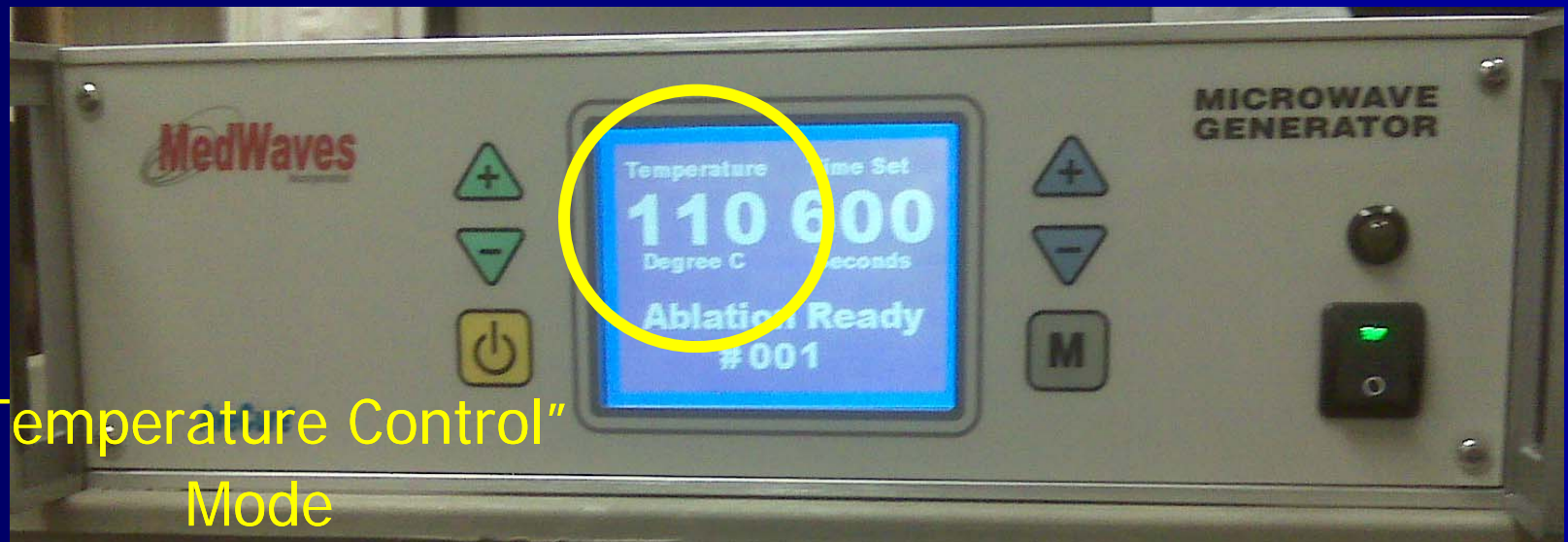


Physical Elements



# Background

## Tumor Permittivity Feedback Control



Power 10-32 Watts

Frequency 902-928 MHz

# Background

Maximize energy deposition within tumor

+

Minimize the reflectivity/reverse power



**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

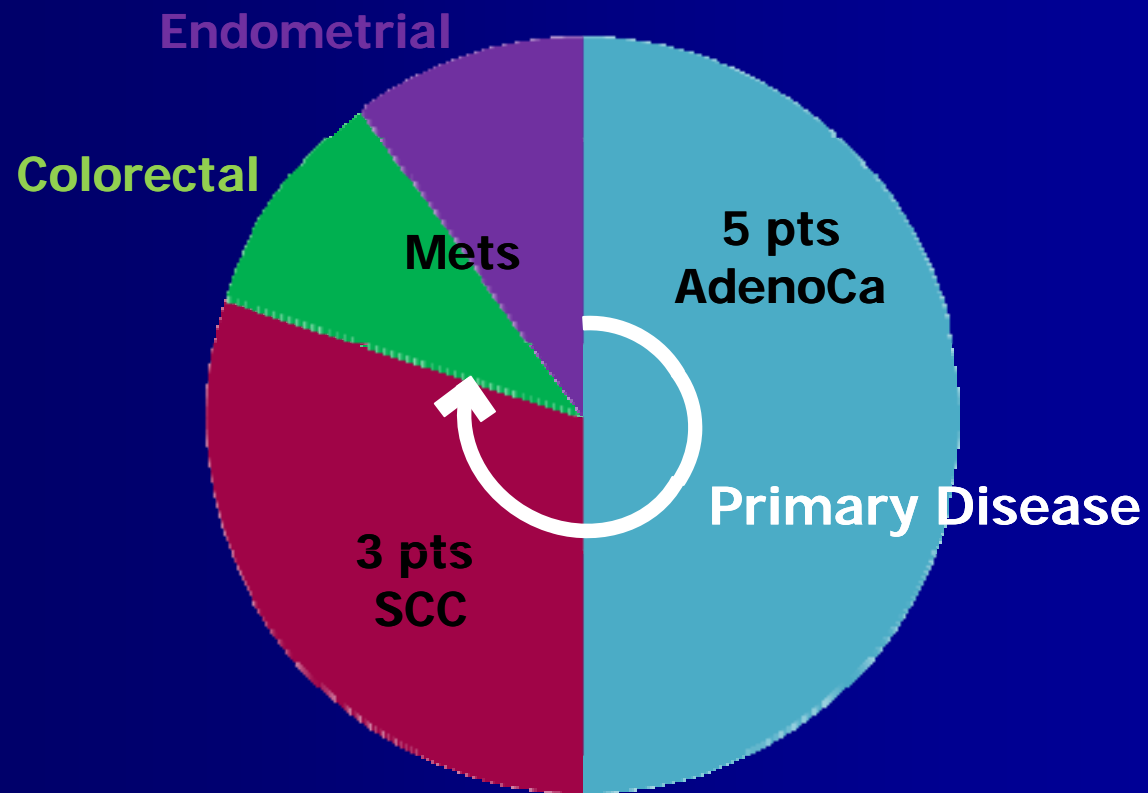
- Surgical resection of a biopsy-proven pulmonary malignancy
- Pre-operative staging CT and PET-CT
- Informed consent obtained prior to enrollment

# 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



# Materials & Methods

## Tumors

- Mean maximum tumor diameter 2.4cm
  - range, 0.9-5.0cm
- Mean tumor volume 8.6cm<sup>3</sup>
  - range, 0.4-53cm<sup>3</sup>

# Materials & Methods

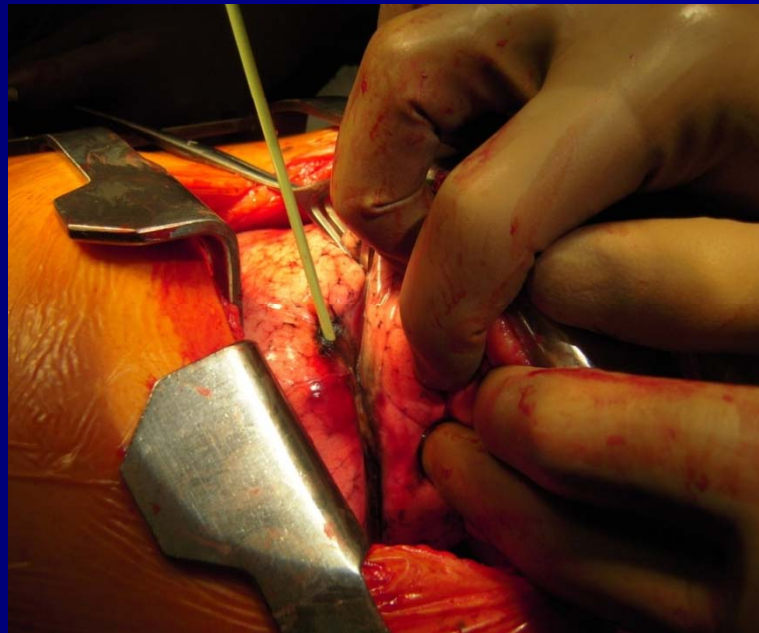
## Ablate & Resect Protocol

- 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

# Materials & Methods

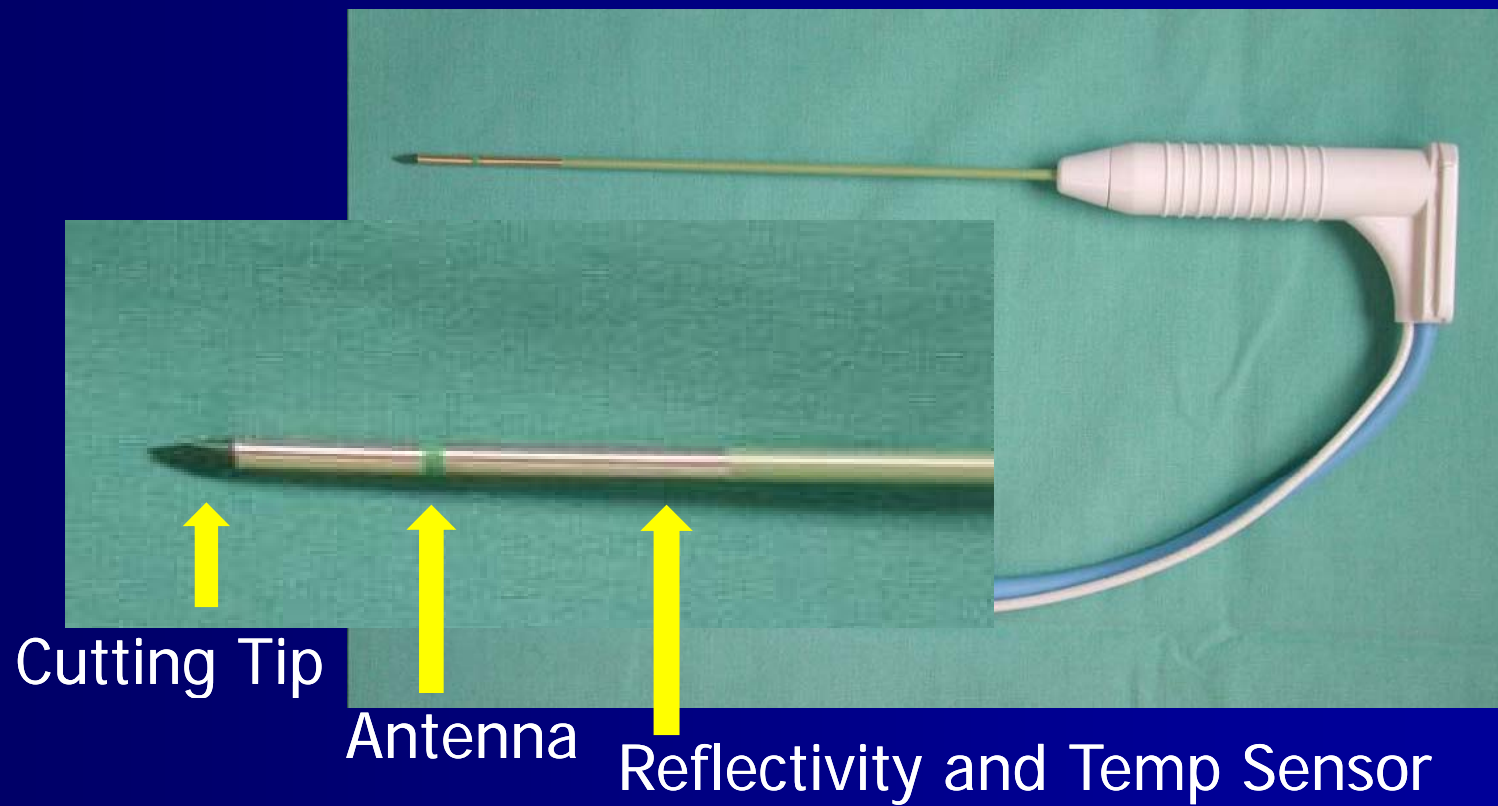
## MWA Technique

- Straight, 14 Gauge, 4cm active tip MW antenna



# Materials & Methods

## MWA Antenna





# Materials & Methods

## 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

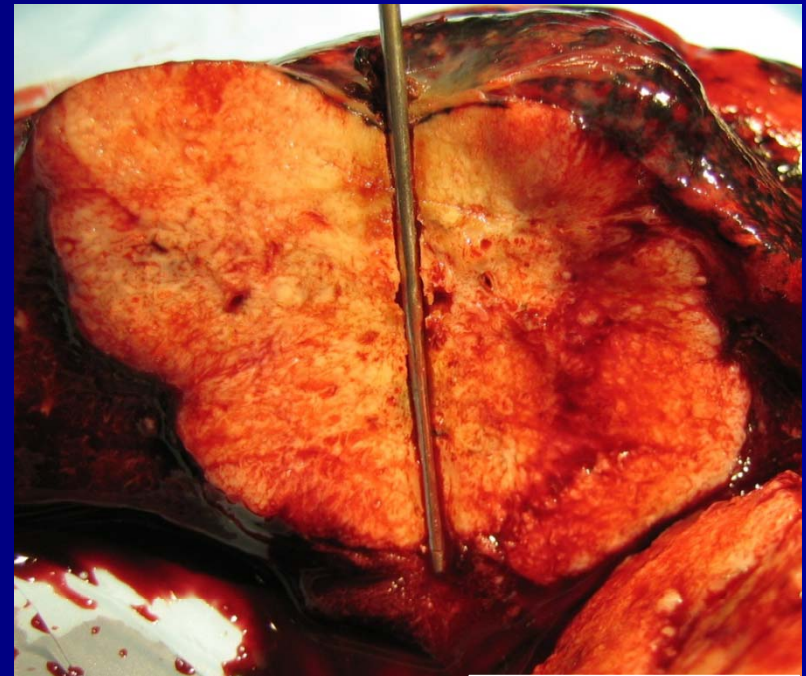
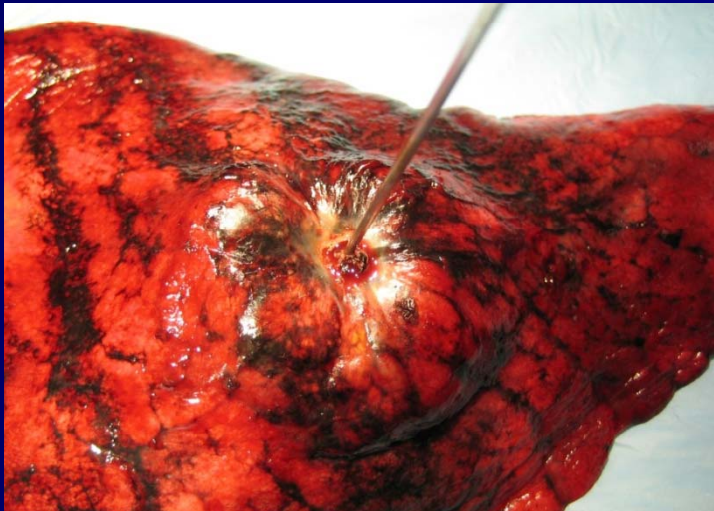
## Ablation Zone Characteristics:

- Ablation zone measurements
  - Grossly measurable in 5 resected specimens
  - Mean maximum diameter 4.8cm
    - (range, 3.0-6.5)
  - Mean volume 15.1cm<sup>3</sup>
    - (range, 7.3-25.1)

# Results: Gross Analysis

## Ablation Zone Characteristics

- Pleural retraction

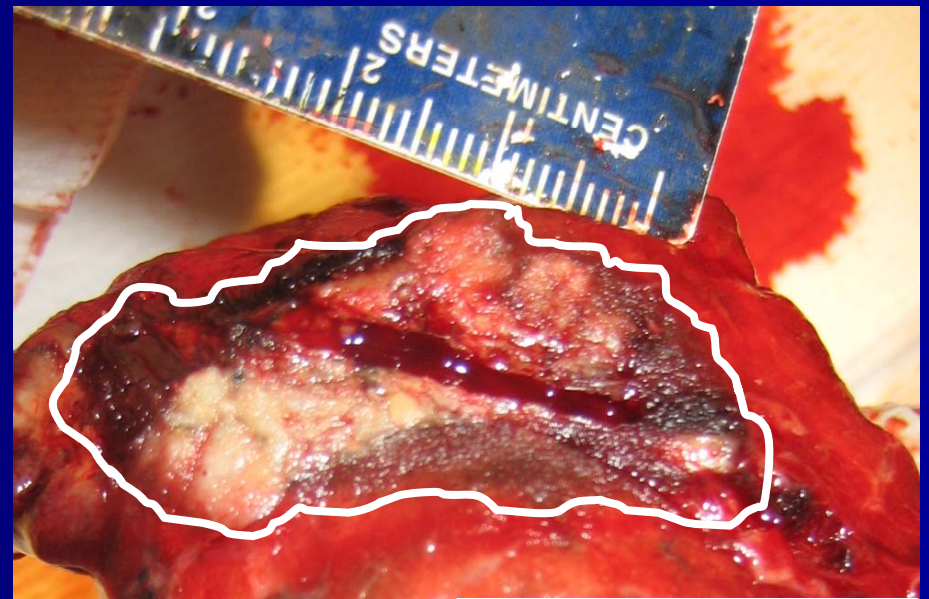
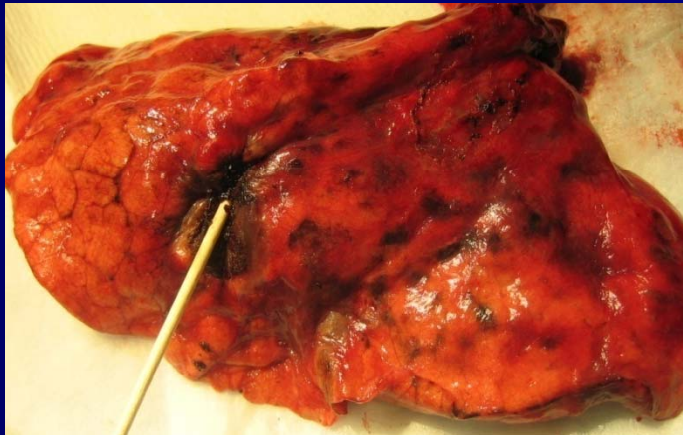


5.0cm, SCC

# Results: Gross Analysis

## Ablation Zone Characteristics

- Hyperemic ellipsoid zone of coagulation necrosis

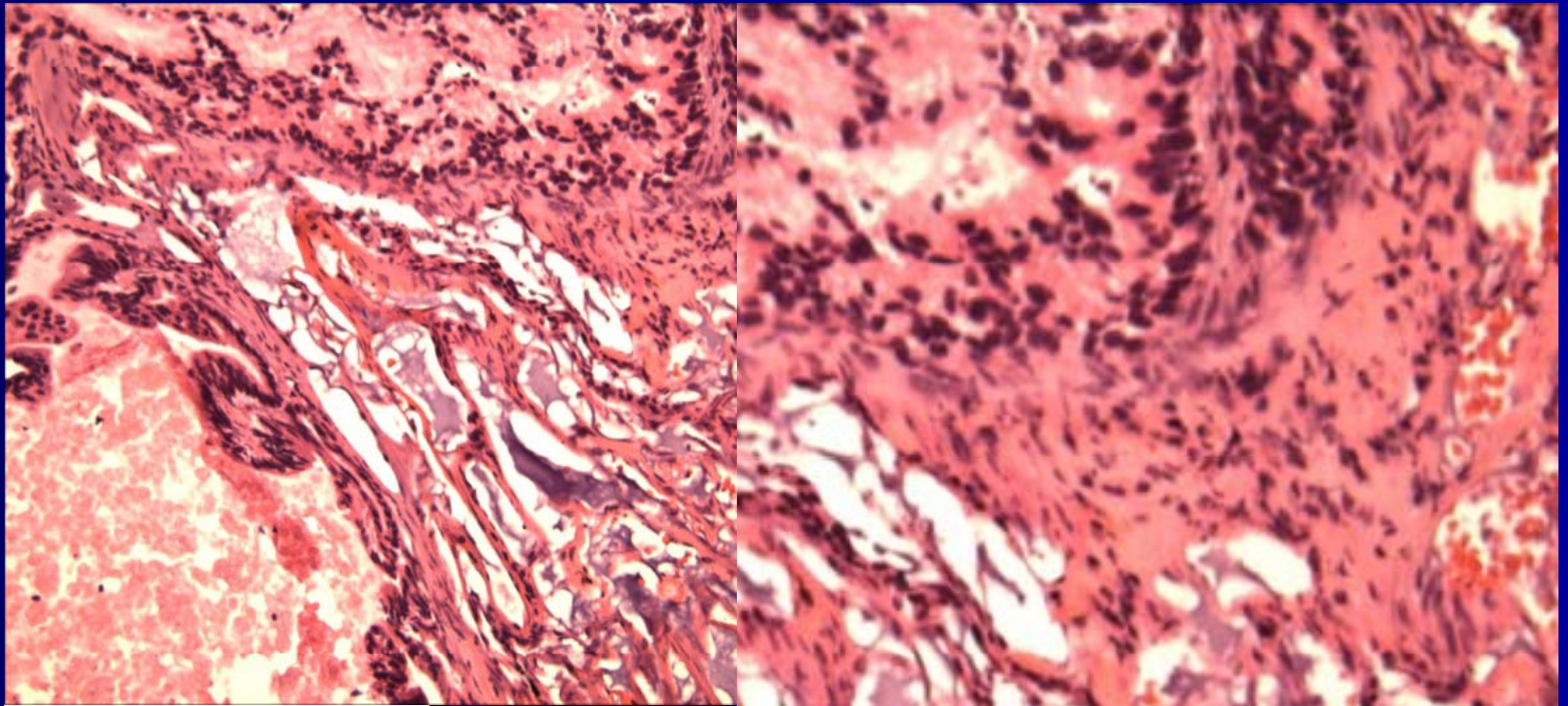


2.5cm, AdenoCa



# Results: H & E Analysis

## Ablation Zone Characteristics

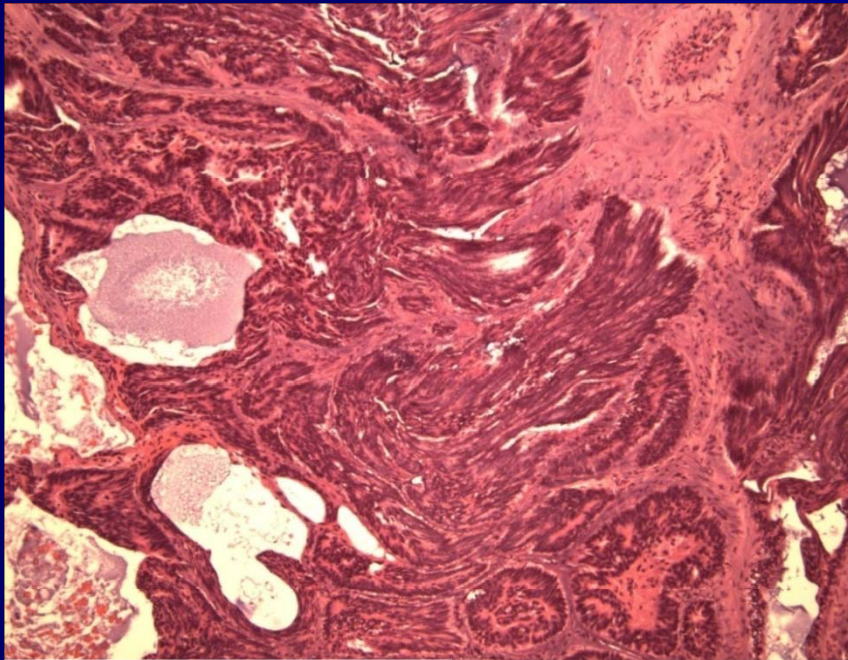


2.5cm, AdenoCa

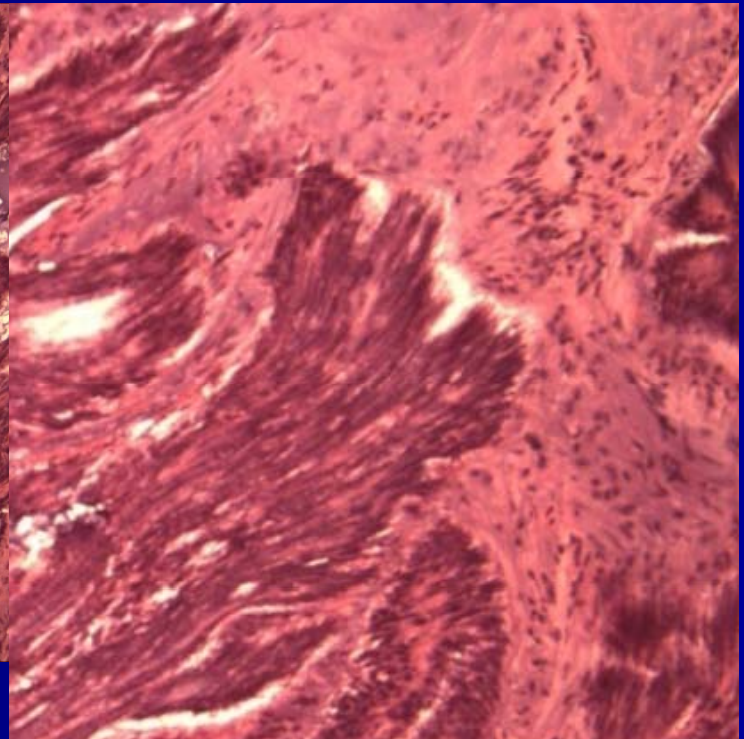
# Results: H & E Analysis

## Ablation Zone Characteristics

- Coagulation necrosis:



2.6cm, CRC Met

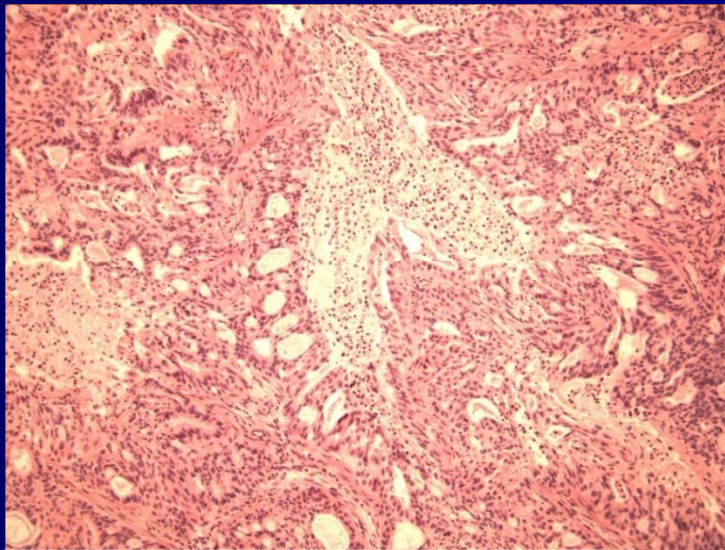




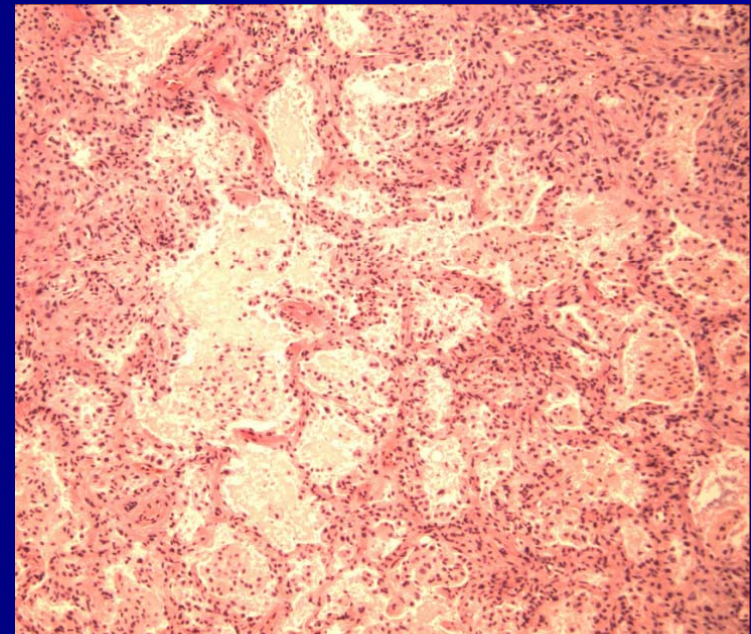
# Results: H & E Analysis

## Ablation Zone Characteristics

- Cytotoxic heating of peri-tumoral aerated pulmonary parenchyma



2.6cm, Endometrial Met



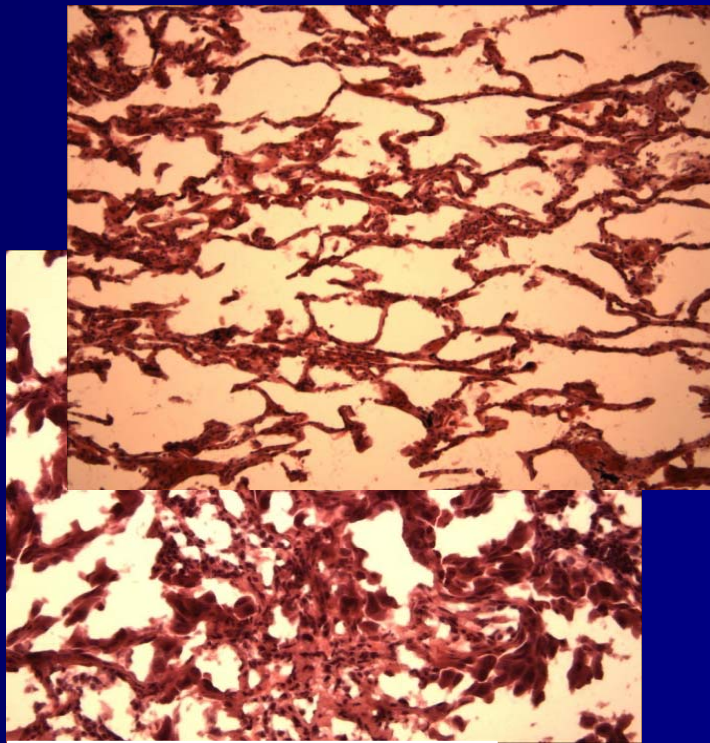


# Results: NADH Analysis

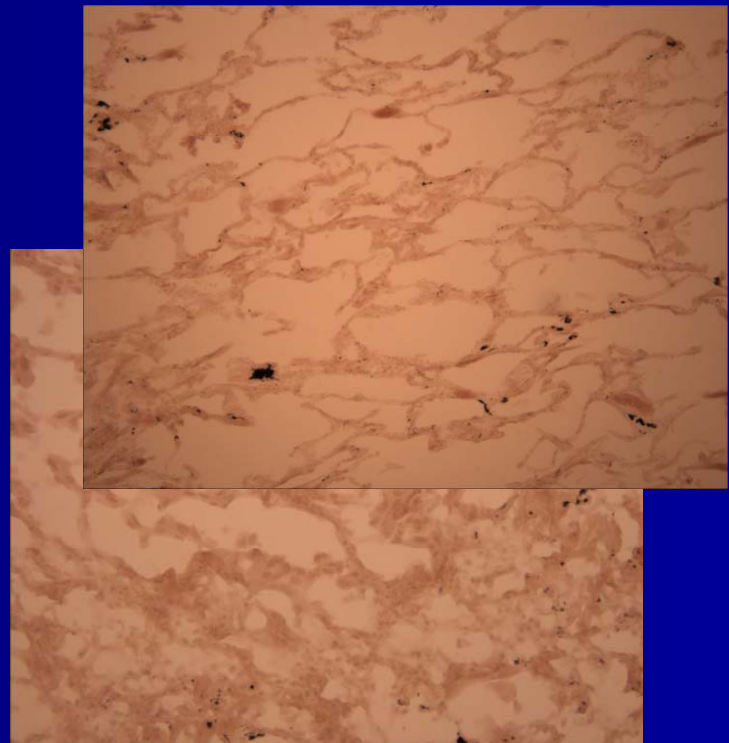
## Ablation Zone Characteristics

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

# Results: NADH Analysis



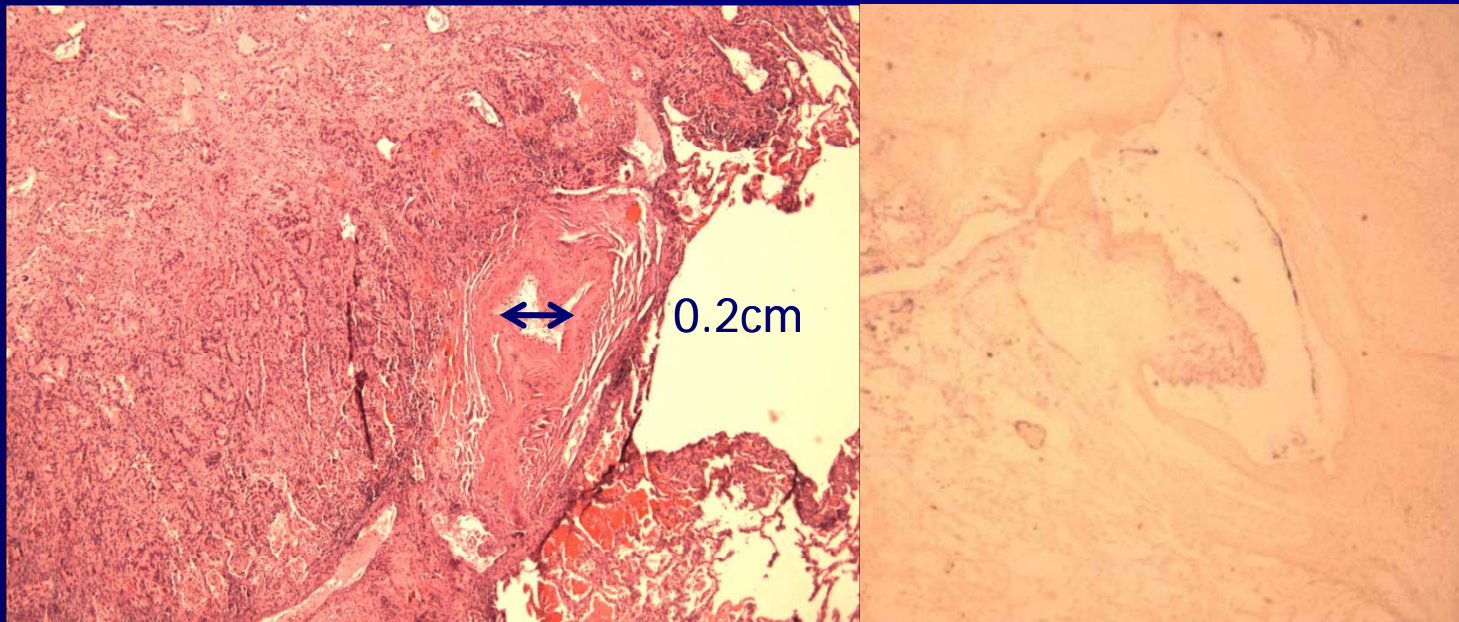
1.0cm, AdenoCa



# Results: NADH Analysis

## Ablation Zone Characteristics

- NADH Staining



2.3cm, AdenoCa

# 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 → significant tissue contraction
    - Up to 52% in center of ablation zone <sup>1</sup>
  - Measure contracted tissue
  - Falsely smaller ablation zone volumes
- Tissue friability → limited gross analysis
- Small cohort size

<sup>1</sup> Brace CL, Diaz TA, Hinshaw JL, Lee FT Jr. Tissue contraction caused by radiofrequency and microwave ablation: a laboratory study in liver and lung. JVIR 2010; 21:1280-6.

# Conclusions

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

**Thank You**

