Lung Ablation: Treatment Options for Localized Lung Cancer

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Disclosure

• Neither I nor my family members have a financial relationship with or have an affiliation with supporting companies or organizations about whose products or services are mentioned in this lecture.

Lecture Outline

• Ablation mechanisms
• Indications
• Identifying the ideal ablation candidate
• Reported outcomes
• Surveillance
• Future directions

Lung Ablation

• Tissue temperatures > 55°C
  — Coagulation necrosis
• Tissue temperatures > 99 °C
  — Tissue dehydration and charring
  — Lower electrical conductivity
  — Increased impedance
• Lung tissue
  — Low electrical conductivity
  — Low thermal conductivity
• Heat sink effect

Radiofrequency Ablation

• Delivery of electrical current to probe tip
• Molecules vibrate rapidly
• Frictional energy loss
• Rise in tissue temperature “the Joule effect”

Radiofrequency Ablation

• Relies on electrical conductivity
• Peripheral tissues heated by thermal conduction
• Limited by charred tissue
Microwave Ablation

• Electromagnetic frequency applied to tissue
• Water molecules continuously realign with field
  – Dielectric hysteresis
• Increased kinetic energy and temperatures
• Thermal conduction
• Not reliant on electric conductivity

Cryoablation

• Release of high-pressure argon at probe tip
• Rapid drop in temperature
• Probe is sequentially cooled and warmed

Irreversible Electroporation

• Non-thermal ablation
  – High voltage pulsed electric field
  – Permanent nanopores
  – Apoptosis
• Respects tissue interfaces

Ablation Mechanisms


Cryoablation

• Rapid Freeze
• Gradual Freeze
• Thaw
• Repeated freeze thaw cycle extends tissue destruction

Practical Implications

• RFA:
  – Target temperature > 57°C < 99°C
  – Probe cooling
  – Impedance based pulsing (<1000 Ω)
• MWA
  – Thermocouple
  – Internally cooled probe
  – Continuous power application
Practical Implications

• Cryoablation
  – Peripheral lesions/sensitive locations
  – No electrical circuit, safe for pacemakers
  – Iceball enables “stick”
  – Target temperature -150°C

Indications

• Medically inoperable stage I non-small cell lung carcinoma
  – Interdisciplinary team
  – Maximum tumor diameter 3-3.5 cm
  – RFA endorsed by NICE and ACCP guidelines
• Solitary pulmonary nodule after standard therapy of stage IIIa lung tumours
• Pulmonary metastases where the primary disease is controlled in a poor surgical candidate

The Ideal Ablation Candidate

• Ineligible for surgical resection
  – Cardiorespiratory comorbidity
  – Insufficient vital lung function
• ECOG status < 3
• Life expectancy > 1 year
• Lesion < 3-3.5 cm
• Lesion > 1 cm from:
  – Trachea
  – Main bronchi
  – Esophagus
  – Central vessels

Exclusion Criteria for Lobectomy

• Major
  – FEV1 < 50%
  – DLCO < 50%
• Minor
  – Age >75
  – FEV1 51-60%
  – DLCO 51-60%
  – Pulmonary hypertension
  – EF < 40%
  – Sp02< 88%

Outcomes

• Limited literature on stage I lung cancer alone
• RFA most studied modality
• Microwave and cryo-ablation data includes:
  – Primary lung and metastatic lesions
  – Varied indications
• Long-term survival data for stage I lung cancer treated with microwave and cryoablation awaited
• SBRT data includes operable patients

Pooled Analysis: Outcomes

<table>
<thead>
<tr>
<th>Modality</th>
<th>Number of studies</th>
<th>Local recurrence (%)</th>
<th>3-year survival (%)</th>
<th>5-year survival (%)</th>
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<tr>
<td>RFA</td>
<td>9</td>
<td>29</td>
<td>36-88</td>
<td>19-27</td>
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<tr>
<td>MWA</td>
<td>1</td>
<td>26</td>
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<td>Cryotherapy</td>
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<td>7</td>
<td>77-88</td>
<td>NR</td>
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<tr>
<td>SBRT</td>
<td>17</td>
<td>7</td>
<td>32-85</td>
<td>28-51</td>
</tr>
</tbody>
</table>
### Surveillance

- **Timing of Imaging**
  - Acquire new baseline imaging within 2 months
  - Image every 3 months for 1st year
- **Caveats**
  - Inflammatory response resolves by 2-3 months
  - Complete disappearance is rare
- **Clinical follow-up**

### Expected CT Appearance

- **Initial**
  - Ground glass halo
  - Consolidation
  - Density increase
- **From 3 months**
  - Four patterns
    - Residual nodule
    - Fibrosis
    - Atelectasis
    - Cavitation
  - Effusion

### Expected PET CT Appearance

- **Initially FDG non avid**
- **3-6 months**
  - FDG avid rim
- **6-12 months**
  - Stable or decreased FDG avid rim

### Recurrence

- **CT**
  - New enhancement in the ablation zone
  - Peripheral nodular growth
  - Change from ground-glass to solid
  - Adenopathy
- **PET**
  - Increased metabolic activity > 2 months post ablation
  - Central or nodular metabolic activity

### Future Directions

- Good quality data for microwave and cryoablation
- Synergistic effect of ablation and radiation
  - Local recurrence rate 9-12%*
- Role for IRE
- Immunologic/molecular agents
  - Ablation may induce anti-tumor immunity
  - Combination with EGFR inhibitors

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*Grasso CA. Vasc Interv Radiol. 2006
Dupuy DE. Chest 2006
Summary

• Alternative therapy for medically inoperable stage I lung carcinoma
• Modalities differ significantly
• Lesion size is critical
• Need for long term data and multicenter trials
  – New ablation techniques
  – Comparison to other therapies
• Clinical and radiologic follow up is important

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