NUKED, FRIED, FROZEN: A PICTORIAL JOURNEY THROUGH PULMONARY CHANGES IN RESPONSE TO DIFFERENT TREATMENT MODALITIES

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DISCLOSURES

- Junjian Huang MD
  - No disclosures

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INTRODUCTION AND BACKGROUND

Lung cancer is one of the most ubiquitous cancers in the world as well as one of the leading causes of cancer related morbidity and mortality.

Surgical lobectomy, whether partial or complete, has long been the gold standard therapy in patients with resectable lung cancer; however, its use is limited in patients who are not suitable candidates for surgery either due to advanced disease or comorbidities.

Image guided energy ablation offers a viable alternative in these patients for palliative treatment. There are currently no randomized control trials comparing the efficacy of various ablative modalities.

Parenchymal changes following ablation have not been well studied and distinguishing from recurrent disease remains difficult.
LEARNING OBJECTIVES

Exploring the CT appearance of lung parenchyma following different types of energy based treatments at several time points following intervention. The ablative modalities reviewed are similar in appearance in that they produce focal changes that tend to decrease in size over time. Also, a brief review of the mechanism of action, indication and technical considerations will be included.

- Radiofrequency Ablation (RFA)
- Microwave Ablation (MWA)
- Stereotactic Body Radiation Therapy (SBRT)
- Cryoablation (CRYO)
RADIOFREQUENCY ABLATION (RFA)

• Mechanism: conduction of electrical current through tissue causing friction and heat. Generates cylindrical lesions in homogenous tissue.

• Indication: primary or secondary lung tumors that are considered inoperable.

• Technical Considerations:
  • Heat sink phenomenon – loss of heat due to circulating fluid creates a nonuniform ablation zone.
  • Char formation – self insulation results in decreased conduction of heat and subsequently decreases the ablation zone.
Axial CT of bronchogenic adenocarcinoma
PET/CT shows bronchogenic adenocarcinoma SUV=6.1.
Axial CT of RFA with needle probe within the mass.
CT 2 week post-op. New area of subpleural wedge shaped consolidation with slightly irregular margins in the region of the lesion, measuring larger than the pre-ablation lesion. Associated mild linear atelectasis and trace left pleural effusion are present.
Scan performed 5 weeks post-intervention shows slightly decreased size of now smoothly marginated subpleural consolidation, which now contains small lucencies. Previously seen trace left pleural effusion has resolved.
Scan performed 5 months post-intervention shows markedly decreased size of ablation changes, now characterized by a small peripheral triangular area of consolidation characteristic of a scar.
MICROWAVE ABLATION (MWA)

- Mechanism: electromagnetic radiation in the 915 MHz – 2.45 GHz range resulting in rapid realignment of polar molecules and resulting in heat production.

- Indication: primary or secondary lung tumors that are considered inoperable.

- Technical Considerations:
  - Not as susceptible to heat sink or char due to electric rather than radiant heating.
  - Due to extreme temperatures above 100° C, water vapor formation and desiccation can degrade visualization of the ablation field.
History of stage 1A Non-small cell lung carcinoma in the right upper lobe, status post right upper lobectomy, with new peri-fissural metastasis.
Axial CT image in lung windows shows the microwave antennae within the lesion.
Axial Ct image in lung windows performed one week post-intervention shows a smoothly marginated ovoid area of consolidation with internal lucencies.
Axial CT image in lung windows from scan performed 6 months post-intervention shows decreased size of the ovoid opacity and resolution of internal air spaces, consistent with retraction of post-ablation scar.
Axial CT image in lung windows from scan performed 12 months post-intervention slight further retraction of post-ablation scar.
STEREOTACTIC BODY RADIATION THERAPY (SBRT)

- Mechanism: high dose hypo-fractionated radiation results in vascular damage in tumors which results in direct and indirect tumor cell death due to immune response.
- Indication: Small primary NSCLC or lung metastases.
- Technical Considerations:
  - Radiation planning: gross tumor, clinical target and planning target volumes.
Axial CT image in lung windows shows a spiculated mass that proves to represent non-small cell lung carcinoma on percutaneous biopsy.
Axial image from PET performed two months later shows the mass to be markedly FDG avid with SUV=32.4.
Axial CT image in lung windows performed one month after completion of SBRT shows a triangular, irregularly margined area of consolidation in the location of the lesion. Underlying metallic structures represent gold fiducials. The original shape of the mass is no longer evident. Fiducials are helpful for targeting during treatment as the lungs are a dynamic organ.
CT performed 6 months after completion of SBRT shows slight retraction of the post ablation scar which maintains a triangular configuration.
Axial CT image in lung windows from CT performed 9 months after completion of SBRT shows relative stability to very slight further retraction of the post radiation scar, allowing for slight technical differences.
Axial CT image in lung windows from CT performed 12 months after completion of SBRT shows the post radiation scar.
CRYOABLATION (CRYO)

- **Mechanism:** Pressurized gas is funneled through a probe and rapid expansion leads to temperature drop in the surrounding environment creating an ice ball. Cryoablation probes are designed to expose local tissue to temperatures on the order of -40°C (lethal) resulting in crystallization of fluid within the cell and resultant lysis during thawing.

- **Indication:** primary or secondary lung tumors that are considered inoperable.

- **Technical Considerations:**
  - Ice ball expands to a preset size- great control over ablation zone
  - Adjunctive maneuvers can be helpful – induce pneumothorax to prevent bronchopleural fistula formation.
  - Extra freeze thaw cycle in the lung vs solid tissues in order to induce edema and hemorrhage for a more complete ice ball as air does not freeze as homogeneously.
Preoperative ct showing pulmonary met.
Pneumothorax assisted placement of cryoablation probe. There induced edema and hemorrhage in the surrounding parenchyma.
Axial CT image in lung windows from CT performed 1 month after completion of cryoablation.
PET CT performed 1.5 months after ablation shows mild SUV uptake compared to background most suggestive of post ablation changes.
Axial CT image in lung windows from CT performed 6 months after ablation shows scar.
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Recurrent LUL pulmonary malignancy after SBRT. Any increase in size of ablated lesion, particularly if nodular in morphology, should alert the radiologist to recurrence. PET may be useful in determining whether the change represents recurrence.


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